DIGITAL SAFETY ANALYZER
Model 501

OPERATOR MANUAL

BIO-TEK
INSTRUMENTS, INC.

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BIO-TEK INSTRUMENTS

DIGITAL SAFETY ANALYZER
MODEL 501
OPERATOR'S MANUAL

MANUAL PART NUMBER 94008

FOR SERIAL NUMBERS 1775 AND UP

REVISION F

NOVEMBER 1986

WARNING

Refer to Section 3.1: Electrical Safety, before beginning to operate the Model 501.

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DOCUMENT REVISION RECORD

Revision, date, and section			Changes
A — E			Revisions prior to addition of document revision record.
F	9/03/86	Entire document	Major rewrite.
		Schematics, components and parts lists	Updated all drawings and parts lists.

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INTRODUCTION TO THE MODEL 501 OPERATOR'S MANUAL

This document is the operator's manual for the Bio-Tek Digital Safety Analyzer Model 501. It contains general information about the Model 501, a description of its components, and instructions for its use. **If a problem develops, the user should contact Bio-Tek at: 1-800-451-5172.** The user should never attempt to service the unit before consulting with Bio-Tek service personnel.

The objectives of the manual are to provide:

1. sufficient information about the design of the Model 501 to enable the user to understand its use (Sections 1 and 2);

2. detailed guidance for maintaining, storing, and shipping the unit (Section 3);

3. procedures for setting up the Model 501 (Section 4), for operating the unit (Section 5), and for calibrating the unit (Section 6); and

4. schematics, component layouts, and parts lists (Section 7).

After becoming familiar with both the Model 501 and this manual, please take the time to answer the questionnaire at the back of the manual. We want your feedback to help us to continually improve our products and our documentation

1 MODEL 501 GENERAL INFORMATION

1.1 Summary of Features

The Model 501 Digital Safety Analyzer is a portable, solid state instrument designed to perform all of the routine tests required to determine if electrically-operated devices, conductive surfaces, and receptacles are electrically safe for use according to national safety standards.

The Model 501 has an internal resistance that duplicates the lowest impedance which the human body offers to the flow of electrical current. By simulating the human body, the Model 501 test results indicate the actual levels that would pass through the body if it were to offer a path for leakage currents.

The Model 501 Digital Safety Analyzer is a precision device designed to make electrical safety testing uncomplicated and rapid. Simple 3-button operation with an autoranging display makes data collection error free. The universal ECG jacks for plugs and snaps facilitate ECG testing. Teh nickel-cadmium battery pack makes all measurements accurate by providing total isolation from the safety analyzer power supply.

A new feature of the Model 501 Safety Analyzer is true RMS measurement. This is the only accurate way to measure complex signals. Other features which increase the efficiency for the user include: compact size, accessories stored on the back panel, self-check circuitry, and modular designed for discrete servicing.

1.2 Applications

The Model 501 provides precise data on the various electrical parameters that will determine if a device is electrically safe for use.

1. As a quality assurance test instrument it provides the means to test devices before thay are placed in service. The Model 501's wide range of testing capabilities indicate whether the device will be safe during normal operating conditions as well as under worst-case conditions.

2. The Model 501, if incorporated into a routine safety program, will provide long-term and immediate benefits. Electrical degradation of a device will be readily evident from records of test results obtained during each electrical safety survey; thus, instruments can be removed from service before they become an electrical hazard.

3. The data will be useful whenever additional purchases of equipment are being considered. By reviewing the amount of repair time required for a given instrument, along with its safety record, it can be decided if repurchasing is a practical idea.

1.3 Testing Capabilities

The Model 501 is designed to perform tests recommended by the majority of nationally recognized agencies in the field of issuing safety standards.

1.3.1 Receptacle Testing

The Model 501 Digital Safety Analyzer is used to test receptacles such as wall units by:

1. determining the polarity of each receptacle,
2. determining if each receptacle is grounded,
3. determining if the metal face plate of the outlet is grounded,
4. measuring the potential differences and resistances between the grounding pole of one receptacle and the grounding pole of any other receptacle.
5. measuring the potential differences and resistances between the grounding pole of a receptacle on one branch circuit and the grounding poles of receptacles on a different branch circuit fed by the same distribution panel, and
6. measuring the potential differences and resistances between the grounding pole of each receptacle and the grounding point that services them.

1.3.2 Portable Devices

The Model 501 tests portable devices such as patient mointors and portable defibrillators by:

1. measuring the potential differences between a device's exposed conductive surfaces and the grounding point that services it,
2. measuring the resistance between a device's exposed conductive surfaces and chassis, and the grounding pin of the plug Measure leakage currents from devices not likely to contact electrically sensitive individuals, and
3. measuring leakage currents from a device when it is:
    1. grounded with normal polarity,
    2. grounded with reversed polarity,
    3. ungrounded with normal polarity, or
    4. ungrounded with reversed polarity.

1.3.1 Equipment with Leads

The Model 501 tests equipment with leads such as ECG/EKG and EEG equipment by:

1. measuring leakage currents from isolated patient leads,
2. measuring the leakage currents from non-isolated patient leads,
3. measuring the leakage currents between leads,
4. measuring potential differences between leads,
5. measuring resistances between leads and exposed conductive surfaces, and
6. measuring isolation of patient leads using 120 V.

1.3.4 Fixed Equipment

The Model 501 tests fixed equipment such as stoves and other appliances as well as CAT-scan, X-ray, and centrifuge equipment by:

1. measuring the potential difference between exposed conductive surfaces of fixed equipment serviced by the same distribution panel,
2. measuring the resistance between exposed conductive surfaces of fixed equipment and the grounding pole of a power receptacle serviced by the same distribution panel,
3. measuring the potential differences between exposed conductive surfaces of fixed equipment serviced by different distribution panels,
4. measuring the resistance between each grounding point and the exposed conductive surface it services, and
5. measuring the leakage currents from exposed conductive surfaces.

1.3.5 Conductive Surfaces

The Model 501 tests conductive surfaces such as operating room floors by:

1. measuring the potential difference between the grounding pole of one of the receptacles and each exposed conductive surface,
2. measuring the resistance of the grounding cord servicing each exposed conductive surface,

3. measuring the potential difference between each grounding point and the exposed conductive surface it services, and

4. measuring the leakage currents from exposed conductive surfaces.

2 MODEL 501 DESCRIPTION

2.1 Model 501 Specifications

MICROAMPS

Range	0 — 199.9, 199.9 — 1999
Accuracy	±1% of full scale
Input Impedance	1000 ohms ±1%
Frequency Response	1000 Hz, DC, per AAMI curve, true RMS
Amplifier Frequency Response	100 kHz, DC, (1 MHz, DC, available)

MILLIVOLTS

Range	0 — 199.9, 199.9 — 1999
Accuracy	±1% of full scale
Input Impedance	1000 ohms ±1%
Frequency Response	1000 Hz, DC, per AAMI
Amplifier Frequency Response	100 kHz, DC, (1 MHz,DC, available)

RESISTANCE

Range	0 — 19.99 ohms ±1% of full scale with 0.01 ohm resolution. Four-point resistance measurement technique. No zeroing required.
Output Current	Maximum output current into 1000 ohms: 300 *u*A (test current is 10 mA)
CALIBRATION	Traceable to the National Bureau of Standards

ONE BUTTON SELF_TEST FEATURES	Low battery indicator Calibration check Digit check
DISPLAY	Large 0.43" (1.1 cm) LED readout
OUTLET CHECK	Push button, 3-neon light readout indicating power, polarity, and ground integrity.
CURRENT CARRYING ABILITY	15 A, 120 V; 6-foot heavy-duty cord, hospital-grade plug and receptacle (other options available, consult Bio-Tek Instruments)
ADDITIONAL FEATURES	Autoranging Ground-to-neutral loop impedance ECG lead leakage ECG isolation test
READING RATE	2 readings/second
POLARITY	Reads true RMS either polarity, or AC with no polarity indication.
ENVIRONMENT	
Operating Temperature	0° to 40° C (30° to 104° F)
Storage Temperature	-25° to 50° C (-13° to 122 ° F)
Humidity	Up to 90% relative humidity
RECHARGEABLE BATTERIES	8-hour operation per charge; 12-hour charge time; 8 subC size, nickel-cadmium batteries in 2 packs of 4 batteries each. (Refer to Section 3.1 for precautions.)

ACCESSORIES	Large probe, clamp, ground adapter, 2 5'-leads, an instruction manual, a short-form manual, and spare fuses.
DIMENSIONS	
Width	8.5" (216 mm)
Height	4.5" (114 mm)
Depth	4.5" (114 mm)
WEIGHT	7 lbs (3.18 kg).

2.2 Description and Location of Model 501 Components

2.2.1 Front Panel

Figure 2.2.1-1 shows the front panel layout; the following numbered items refer to the numbers in the figure:

1. **Function Selector Buttons:** The grey button controls OFF/ON. The blue buttons are selectors for Systems Check, ECG Lead Testing, Ground Wire Resistance and Chassis Leakage Testing.

2. **Digital Display:** Bright light emitting diodes (LED) digits indicate the magnitude of the measurement with automatic range selection.

3. **Status Indicators:** These LED indicators monitor system performance and light to indicate battery charging, low battery voltage and overrange condition.

4. **Receptacle Check Lights:** Indicate wall receptacle condition when the SYSTEMS CHECK button is pushed.

5. **Lead Wrap:** Allows storage of test leads during transport of the Model 501.

6. **Outlet Light:** Indicates that power is applied to the test receptacle.

7. **Test Receptacle:** The hospital-grade test receptacle brings the test point to the front panel for easy testing.

8. **Polarity Switch:** This switch reverses the polarity of the test receptacle for complete product testing.

9. **Ground Switch:** Breaks the ground wire for the device to allow complete testing.

10. **Red Lead/Black Lead Input Jacks:** The signal to be measured is applied between the red and black input jacks or if shorting bars are used, between the red lead and ground.

11. **Ground Jacks:** Most measurements are ground referenced and the ground jacks allow easy connection to the power system ground.

12. **Operator Danger Light:** When signals that exceed 70 V are applied to the signal inputs, this indicator is lit.

13. **ECG Lead Selector:** Selects the ECG lead for leakage and isolation testing. It also provides inter-lead testing.

14. **Ground-to-neutral Button:** Allows measuring power systems ground integrity with a push of a button.

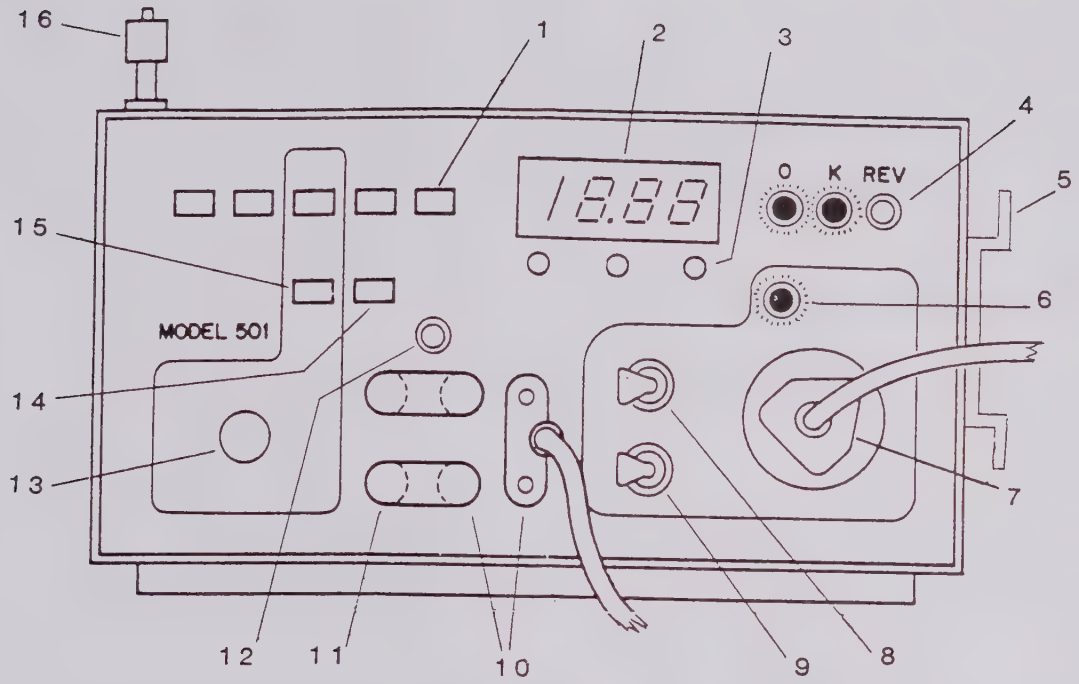

Figure 2.2.1-1. Model 501 Front Panel

15. **ECG Lead Isolation Button:** Applies 120 V through 300K ohms to each ECG lead.

16. **Universal ECG Adapters:** Has snaps and receptacles for all ECG connectors.

17. **Screw Securing Panel to Interior Strengthening Bar:** Refer to Appendix A for removal of front panel.

2.2.2 Back Panel

Figure 2.2.2-1 shows the back panel of the Model 501; the following numbered items refer to the numbers in the figure:

1. **Chassis Ground Connector:** Knurled nut provides easy connection to the chassis of the Model 501.

2. **Probe Clip:** For storing the probe.

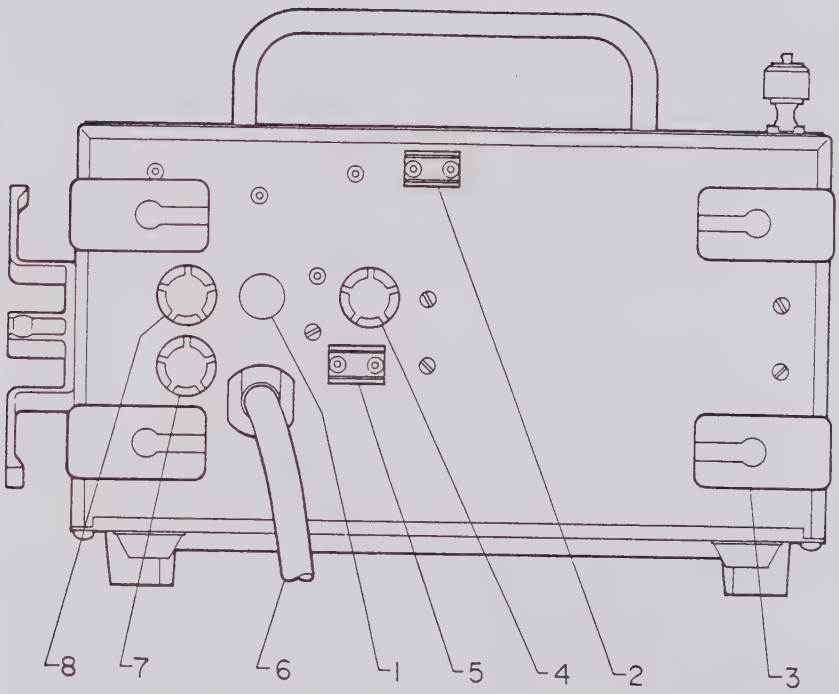

Figure 2.2.2-1. Model 501 Back Panel

13. **Cord Wrap:** Provides storage for the line cord and acts as feet for using the Model 501 on its back.

4. **Ohms Fuse:** The 1/4 A fuse protects the ohms circuit from damage if the Model 501 is connected to high voltage during resistance measurements.

5. **Ground Adapter Clip:** Stores the banana jack-to-ground pin adapter.

6. **Line Cord:** Heavy duty line cord.

7. **Outlet Fuse:** 15 A slow-blow fuse which protects the test receptacle and the device under test from overloads.

8. **Battery Charger Fuse:** A 1 A fuse protects the battery charge circuitry from any over-voltages or current.

2.3 Accessories

Figure 2.3-1 shows the accessories that are supplied with the Model 501. Bio-Tek part numbers are listed for use in ordering extra accessories.

2.4 Optional Accessories

2.4.1 Model CC3 Carrying Case

The Model CC3 is a custom carrying case designed to conveniently and safely transport your Model 501 and all of its accessories. The exterior is constructed of durable thermoplastic with a shock-absorbent polyfoam interior.

This tough aluminum, reinforced case comes with a full 5-year guarantee against all defects in materials and craftsmanship. Order using Bio-Tek part number 93090.

The Model CC3 has the following features:

1. heavy duty ABS exterior,

2. shock-absorbent polyfoam interior,

3. rugged steel-core handle and draw-bit lock, and

4. all edges and corners reinforced with aluminum.

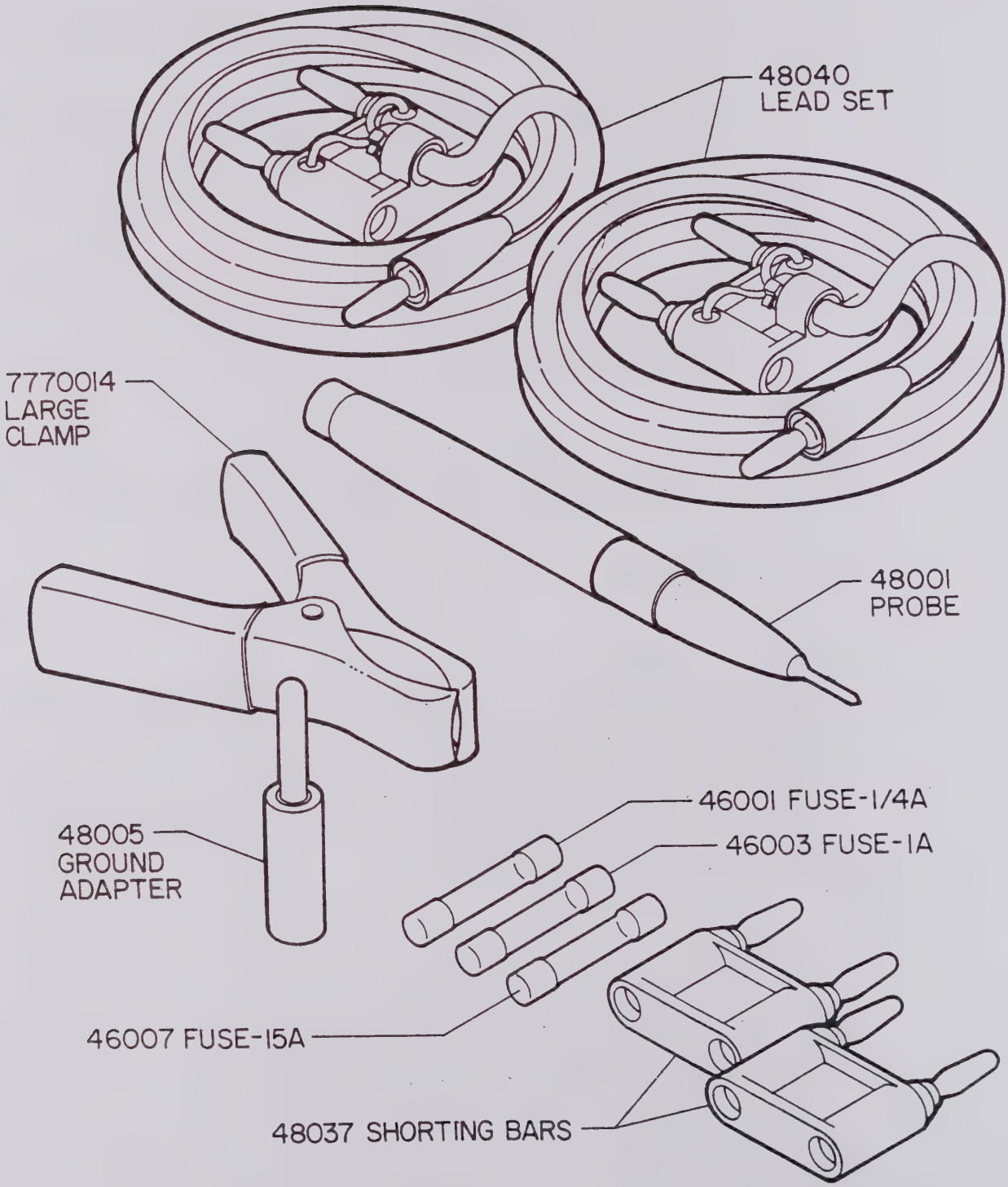

Figure 2.3-1. Model 501 Accessories

2.4.2 Recordkeeping and Tagging

Bio-Tek Instruments has a complete Recordkeeping and Tagging system available that will fit into any program. Write or call the Sales Department, Bio-Tek Instruments, Inc., Highland Park, Box 998, Winooski, Vermont 05404-0998, 800-451-5172 for information.

2.5 Theory of Operation

The operation of the Model 501 can be divided into 6 systems:

1. Microamp/Millivolt Amplifier,
2. Ohms System,
3. Digital Voltmeter,
4. Power Supply,
5. Input Switching, and
6. Test Receptacle.

Each system of the Model 501 is described in general to define the overall operation of the Model 501; refer to the block diagram in Figure 2.5-1 as an aid to explanation.

2.5.1 Microamp/Millivolt Amplifier — Leakage Current

The input microamp/millivolt section, with over 20 Mohms of input impedance, is in parallel with the AAMI test load. The signal is amplified by an operational amplifier in the noninverting mode. The gain of this amplifier is controlled by an autorange control circuit which, in turn, is driven by the Digital Voltmeter integrated circuit as a by-product of the A/D conversion process.

The output of the amplifier goes directly into the precision RMS-to-DC converter. This converter takes any signal, positive or negative, DC to 1 MHz, and converts it into a DC voltage that is equal to the root mean square of the input signal.

This DC voltage is then measured by the Digital Voltmeter Section and displayed in *u*A/*u*V.

2.5.2 Digital Voltmeter

The Model 501 Digital Safety Analyzer uses a precision analog-to-digital converter system which converts the analog voltage into timed pulses which are counted and displayed on the light emitting diode (LED) display. The number of pulses is directly equal to the analog voltage. The converting system also senses the voltage and

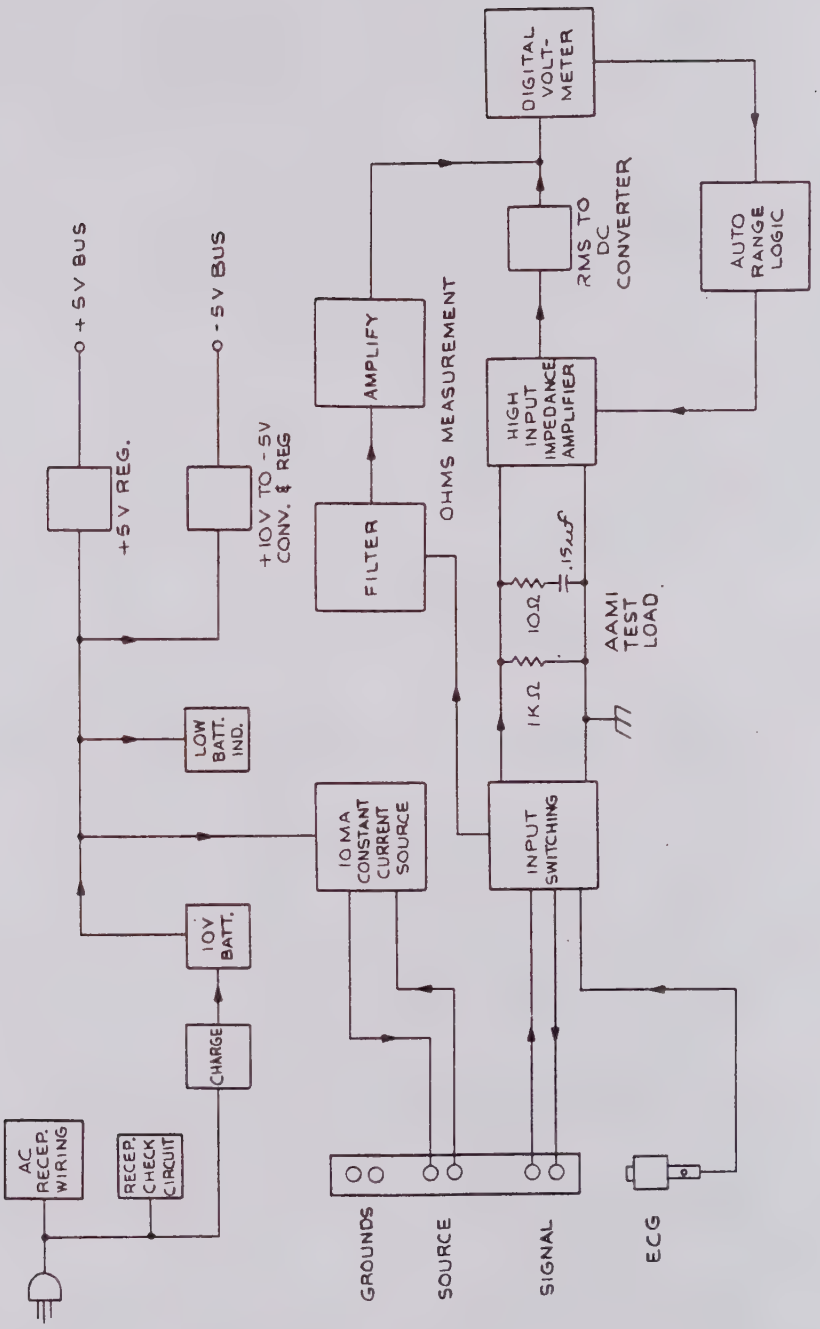

Figure 2.5-1. Model 501 Block Diagram

determines the correct range. This signal is fed to the autorange control which in turn controls the gain of the amplifier system.

2.5.3 Ohms System — Ground-wire Resistance

To measure resistances, the Model 501 uses the precise Four-Point Resistance Technique. Current (which induces a voltage) from an isolated constant current source is fed directly to the resistance to be measured. This negates the accumulated resistances of leads and lead jacks should the current be fed through them. (For a complete discussion of the Four-Point Technique, refer to Appendix C.)

The constant current source is powered by an isolated power supply. This power supply consists of an oscillator, a step-up transformer (which provides the actual isolation), and bridge rectifier. The current source consists of a dual-operational amplifier, designed to provide a constant current over a broad range of test resistances and power supply voltages.

The signal (induced by the constant current source and measured by the signal input leads) is first filtered to minimize effects caused by a stray 60 Hz signal and then amplified and read by the digital voltmeter (DVM).

2.5.4 Input Switching

The input switching provides easy use by making or breaking all connectors needed for each function. The switches are interlocked for 1-button operation and have mechanical lockout to prevent damage or misinterpreted readings.

2.5.6 Power Supply

The power supply consists of a battery charger, a 10 V nickel-cadmium battery pack, and +5 V and -5 V regulators.

The battery is connected to the circuit during instrument operation and to the charger when the Model 501 is OFF. The battery voltage goes to a low battery indicator that monitors battery voltage and activates an LED when the voltage drops below a presribed value.

The +5 V comes from a +5 V integrated circuit regulator. The -5 V is provided by a DC-DC (+10 to -7) converter that then passes through a voltage regulator.

If your Model 501 was designed for 110 VAC, it can still be plugged into a 220 V power supply to test 220 V equipment.

1. Plug the Model 501 into a 220 V power supply for testing **only** if your Model 501 is fully charged.

2. The Model 501 must **not** be in the OFF/CHARGING mode while plugged into a 220 V power supply.

NOTE: These precautions do not apply to models designed for use at 220 V.

2.5.6 AC Test Receptacle

The Model 501 allows the operator to alter the AC power supply configuration on the device under test. The test receptacle is connected to the AC line by toggle switches that alter polarity and ground.

The AC line is also connected to the receptacle check circuit during Systems Check. The receptacle check circuit connects a resistor network and 3 neon lights in a configuration that indicates AC line status.

3 SAFETY, MAINTENANCE, STORAGE, SHIPPING, AND WARRANTY

3.1 Electrical Safety

Read this section carefully before beginning to operate the Model 501.

1. Inspect the power cord periodically for cracks and frays.
2. Disconnect the power cord when opening the Model 501 for any reason.
3. Before using the Model 501, the protective earth terminal (chassis) must be connected to the protective earth contact. **Do not disable this protective action by using an extension cord or *cheater plug* that does not have a protective ground conductor.**

   NOTE: The Model 501 is shipped with a 3-wire cable; when the cable is connected to an appropriate AC power source, this cable connects the chassis to earth ground.

Adhere to the following cautionary notes to avoid damage to the Model 501:

CAUTIONARY NOTES

1. When testing a defibrillator for chassis leakage, do not discharge the defibrillator.
2. When measuring the leakage current of a motorized instrument, do not abruptly reverse the polarity. Place the polarity switch in the OFF position until the motor has stopped, then move it to the desired position.

   NOTE: Blown polarity switches are not covered under warranty.
3. Do not use the instrument at line voltages other than what it was designed for without consulting the factory.
4. When using this instrument with a Bio-Tek Model 12 tester, depress the Chassis leakage button before connecting the Model 12.
5. To insure long life of your 501's nickel-cadmium batteries, avoid completely discharging the 501 (discharging until the battery is dead. To avoid completely discharging, we recommend that once the Model 501 LO BAT signal comes on, you should recharge the Model 501 (14-16 hours maximum charging time).

NOTE: Overcharging of the 501 will result in a marked decrease in battery life. Bio-Tek Instruments does not warrant fuses or batteries in any instrument.

6. If your Model 501 was designed for 110 VAC, you can still plug it into a 220 VAC power supply to test 220 VAC equipment, as follows:

    1. Plug your 501 into a 220 VAC power supply for testing, ONLY if your Model 501 is in the fully charged condition.

    2. Under no condition should the 501 be in the OFF/CHARGING mode while plugged into a 220 VAC power supply. (These precautions do not apply for models made for 220 VAC.)

3.1.1 Operator and Patient Safety

It is imperative that an operator of the Model 501 adhere to the following safety procedures to ensure his or her own safety and the safety of patients:

1. Do not use the Model 501 on equipment connected to a patient. Certain tests produce dangerous leakage currents.

2. Do not use the Model 501 to test receptacles if patient-connected devices are operating on the same circuit.

3.1.2 Establishing Safety Standards

This manual does not include suggested acceptable levels for each test procedure because of variation in acceptable standards presently being suggested and enforced by the various agencies, organizations, and institutions.

Each test should be performed in accordance with the test procedures presented in this manual, but refer to your safety program's specifications to determine if the results obtained are acceptable, or if the item tested should be repaired or replaced.

If you have questions concerning standards, write to the appropriate agency, or write to Bio-Tek Instruments for information; please specify the application and area of concern. Bio-Tek Instruments publishes manuals on safety testing; to order, request Bio-Tek's Electrical Safety Primer and Electrical Safety Guide.

3.2 Maintenance

The Model 501 may be maintained and serviced by users knowledgeable in electronic repair. Refer to Section 2.5: Theory of Operation, and Section 7: Schematics, Component Layouts, and Parts Lists; these sections should provide the information necessary to maintain and service the Model 501 Digital Safety Analyzer.

We recommend that the Model 501 be recalibrated annually. Calibration instructions are found in Section 6. If the purchaser does not possess the necessary equipment for proper recalibration, return the Model 501 to Bio-Tek. The instrument calibration is traceable to the National Bureau of Standards (NBS). For recalibration of further service, pack the Model 501 according to the shipping procedures provided in Section 3.3, addressed to:

Service Department
Bio-Tek Instruments, Inc.
Highland Park, Box 998
Winooski, VT 05404-0998

3.3 Storage and Shipping

STORAGE

The Model 501 should be stored on a flat surface that is relatively free of vibration. The storage environment should be free of dust and other foreign particles. If the optional carrying case has been purchased, store the Model 501 in the case whenever the instrument is not in use.

The Model 501 can be stored under the following environmental conditions:

1. temperature: -25° — 50° C (-13° — 122° F), and
2. humidity: up to 90% relative humidity.

The Model 501 should be protected from temperature extremes that can cause condensation within the unit and from corrosive fumes and vapors.

SHIPPING

When the Model 501 is shipped to Bio-Tek for service or repair, the unit must be shipped in the orignal packaging; other forms of commercially available packing are not recommended and can void the warranty. If the original packing has been damaged or lost, contact Bio-Tek for replacement packing (call: 1-800-451-5172 or telex: 94-0136 BIO TEK SHVT).

The Model 501 must be repacked according to the following procedures:

1. Place the styrofoam protective end caps on the Model 501 and place within the box.
2. Seal the packing box.
3. Mark the box as **Fragile.**

Before the Model 501 is returned to Bio-Tek, make sure you have addressed each item in the following check list:

1. Obtain a **Return Authorization Number** from Bio-Tek's customer service representatives (call: 1-800-451-5172 or telex: 94-0136 BIO TEK SHVT).

2. Include a statement of what is required of the Bio-Tek Service Department (state whether the unit requires calibration, cleaning, or repair).

3. Include a tag that includes the Return Autorization Number, the full model number, and the serial number.

4. Provide Bio-Tek with the name and telephone number of whom Bio-Tek should contact with any questions.

5. Insure the Model 501 for full value.

The Model 501 can be shipped under the environmental conditions stated within this section under STORAGE.

3.4 Warranty

Bio-Tek warrants the Model 501 to the original purchaser for a period of 1 year from the origianl purchase date. The warranty is for normal use and service, against defective materials or workmanship. If the customer ships the Digital Safety Analyzer to Bio-Tek, postage pre-paid, and Bio-Tek determines the defect to be in materials or manufacturing, Bio-Tek shall either repair or replace the unit at Bio-Tek's option, without cost to the customer.

This warranty is void if the Model 501 has been visibly damaged by accident, misuse, or has been repaired or alterd by persons or stations not autorized by Bio-Tek, or has had the serial number altered, defaced, or removed.

Bio-Tek Instruments reserves the right to discontinue the Model 501 at aby time and to change the specifications, price, or design without notice and without incurring any obligation.

Bio-Tek will continue to stock service parts for up to 5 years after the manufacture of the unit has been discontinued. Parts shall include all materials, charts, instructions, diagrams, and accessories that are furnished with the unit.

The purchaser agrees to assume all liability for any damages or bodily injury that may result from the use or misuse of the unit by the purchaser, his employees, or customers.

INSTALLATION

4.1 Unpacking and Inspection

When you receive the Model 501, inspect he shipping carton for damage. If the shipping carton is damaged, unpack the instrument and note any dents and scratches on the Model 501. **Immediately notify Bio-Tek that the Model 501 was damaged in shipping.** Bio-Tek will arrange repair or replacement of your instrument without waiting for the settlement of the claim against the carrier. **Retain the damaged shipping carton and packing material for the carrier's inspection.**

5 OPERATION

5.1 Overview

This section contains information for operating the Model 501 Digital Safety Analyzer.

The Model 501 is designed to perform routine tests to determine if electrical devices, conductive surfaces, and receptacles are electrically safe for use according to recognized safety standards.

5.1.1 Operating Environment

The Model 501 may be operated in environments where the temperature range is 0° to 40° C (32° to 104° F) and the relative humidity is up to 90%. The instrument should be protected from drastic changes in temperature that can cause condensation within the instrument and from corrosice vapors and fumes.

5.1.2 Operating Precautions

If you have not done so, read Section 3.1: Electrical Safety; the precautions specified in Section 3.1 **must** be followed.

5.2 Operating the Model 501

5.2.1 Empowering the Model 501

Connect the 3-wire cable from the Model 501 to the appropriate AC power source.

CAUTION: If the Model 501 is plugged into a 220 V power source, do **not** shut the instrument OFF to charge the batteries.

5.2.2 Systems Check

The Systems Check should be performed **before** testing each day and when connecting to a new receptacle for testing.

5.2.2.1 Systems Check — Definition

Systems Check is a general procedure that ensures proper operation of the Model 501 and the AC power system (see Figure 5.2.2.1-1):

1. Verifies Model 501 calibration with an internal 188 mV reference (the display reads 18.88).

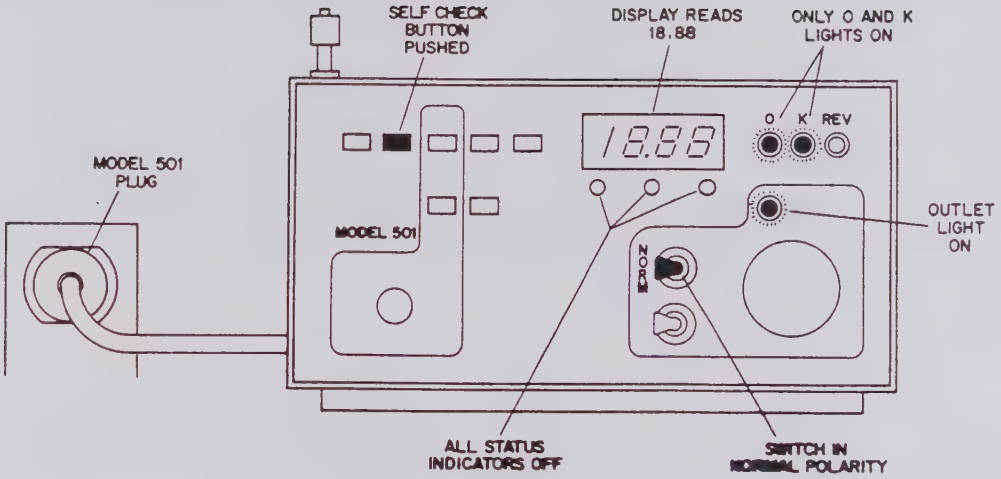

Figure 5.2.2.1-1. Model 501 Self-check Configuration

2. Verifies operation of the LED digits by lighting all segments of each digit to 1888.
3. Tests the receptacle to which the Model 501 is connected for power, polarity and ground, using the 3-neon light read-out system.

   NOTE: The receptacle test is invalid when testing in an Isolated Power System area. An explanation is contained in Section 5.2.3.

4. Checks the battery using the low battery indicator light. (The LO BAT indicator light also works on any function).

5. Checks the fuse to the Model 501 receptacle using the outlet light. (The receptacle POLARITY SWITCH is in NORM position.)

5.2.2.2 Systems Check — Problem Analysis

1. Display does not read 18.88:

   1. The first cause could be extremely low batteries whose voltage is below the ON-threshold for the low battery indicator. The solution is to connect the Model 501 to a powered receptacle overnight in the OFF/CHARGING mode.

   2. After storage in temperatures that approach 0° C (32° F) or in excess of 40° C (104° F), the Model 501 may read 18.98 or 18.78. Allow the unit

to return to room temperature and the display should return to 18.88. In any event, the unit will be accurate within 1% even though the display reads 18.98 or 18.78 under extreme temperature conditions.

3. If the display reads anything other than 18.88, 18.98 or 18.78, and the batteries are charged (the Model 501 has been plugged in overnight), the unit may be malfunctioning or the digital display may be damaged. It is recommended that the unit be returned to the factory. Refer to Section 3.3 for shipping and service information.

2. LO BAT indicator in ON:

   1. Plug the Model 501 into a receptacle and push the OFF/CHARGE button. Be sure the charging light is ON. Charge for 12 hours.

   2. The LO BAT indicator is operational during testing and may come on at anytime. Even through the low battery indicator is ON there are still one-to-two hours of constant use time left in the batteries. It is important that systems check be performed under low battery conditions to verify proper operation.

3. Neon lights indicate status other than proper O K configuration:

   Refer to Section 5.2.3: Receptacle Testing, for analysis.

5.2.3 Receptacle Testing

The Model 501 allows comprehensive testing of ground-referenced power system receptacles. Receptacles are tested for neutral-to-ground resistance, polarity, ground, and power. Resistance between two receptacles and potential difference between two receptacles can also be tested.

NOTE: Polarity testing and neutral-to-ground resistance testing are not valid for an Isolated Power System (IPS). This is because in an IPS there is no *hot* or *neutral* nor is either side of the power outlet connected to earth ground as in a conventional ground-referenced power system.

5.2.3.1 Polarity Testing

1. Plug the Model 501 into a receptacle.

2. Push the SELF CHECK button.

3. The neon lights should read O K; if not, refer to the neon light Read-Out chart in Figure 5.2.3-1.

O	K	REV	
●	●	O	Normal Polarity and Ground
●	O	●	Reversed Polarity
●	O	O	No Ground
O	●	O	No Neutral
O	O	●	No Neutral with Reversed Polarity
O	O	O	No Power

O = unlighted
● = lit

Figure 5.2.3-1. Neon Light Read-out Chart for Receptacle Testing

5.2.3.2 Neutral-to-ground Resistance Testing

1. Plug the Model 501 into a receptacle.
2. Push the SELF CHECK button.
3. Push the NEUTRAL-TO-GROUND RESISTANCE button.
4. Subtract 0.20 ohms from the NEUTRAL-TO-GROUND reading. The 0.20 ohms is the approximate resistance of the internal connectors and wires of the Model 501.

5.2.3.3 Receptacle-to-receptacle Testing of Resistance or Potential Difference

1. Use the single-lead setup shown in Figure 5.2.3.3-1 and:
    1. Place a shorting bar between the top green banana jack and the top black banana jack.
    2. Place the other shorting bar between the bottom green and black banana jacks.
    3. Connect the dual plug of the red lead to the two red jacks.

2. Plug the Model 501 into a receptacle.

3. Attach the ground adapter to the read lead which is connected to the Model 501.

4. Plug the ground adapter into another receptacle.

5. Put Ground switch on GROUND.

6. Push the GRD Wire Resistance button. The resistance between the receptacle that the Model 501 is plugged into the receptacle with the red lead input is measured.

7. By pushing Chassis Leakage, the potential difference in millivolts is measured.

NOTE

OBSERVATION: Sometimes during the neutral-to-ground resistance testing the Bio-Tek Model 501 Electrical Safety Analyzer may give erratic readings.

During this test procedure the safety analyzer applies a fixed current (10 mA DC for the Model 501) between the neutral and ground wires. The resulting voltage drop caused by the unknown resistance between the two wires is measured with as amplifier. A measure of this voltage drop is displayed by the analyzer as the resistance between the neutral and ground wires.

EXPLANATION: The amplifier circuit mentioned above also has a low-pass filter that rejects 50 or 60 Hz, 100 mV line interference. However, it is not unusual for much-larger amplitude signals (several volts), of 50/60 Hz or other frequencies, to be floating in the hospital wiring system. These interferences may be attributed to improper wiring, sheilding, distribution system, or grounding. Ground loops and/or appliances and equipment (CAT Scanners, X-Ray equipment, etc.) used in the hospital may also contribute to extraneous signal levels.

SOLUTION:

1. Perform the test with all other appliances and devices connected to the same distribution system unplugged.

2. If the erratic readings persist, you can make a choice between eliminating this test or taking steps to have a better wiring, distribution and grounding system.

REMEMBER: The neutral-to-ground resistance test is not required by any national or international standards.

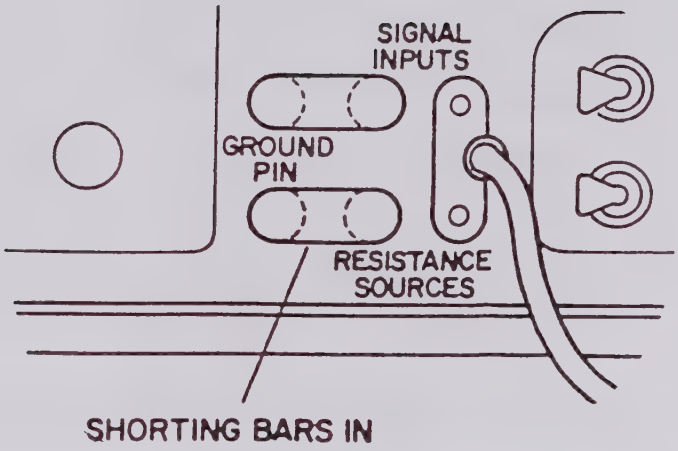

Figure 5.2.3.3-1. Single-lead Setup for Receptacle-to-receptacle Testing

5.2.4 Portable Device Testing

This section describes how to test devices that have an accessible 3-prong, 15 A plug. If the devices are permanently wired, refer to Section 5.2.6 for testing procedures.

CAUTION

When testing defibrillators for leakage current, **do not** discharge the defibrillator because damage to the Model 501 could result.

5.2.4.1 Setup

1. The single-lead is the same as that shown in Figure 5.2.3.3-1:

    1. Place one shorting bar between the top green banana jack and the top black banana jack.

    2. Place the other shorting bar between the bottom green and black banana jacks.

    3. Connect the dual plug of the red lead to the two red jacks.

    NOTE: These shorting bars connect one side of the measuring system to earth ground during chassis-leakage measurements and to the Model 501 receptacle ground pin during ground-wire resistance measurements.

2. Attach the large clamp to the single red banana plug on the lead.

3. Plug the Model 501 line cord into a receptacle.

   NOTE: If the devices to be tested are located in an Isolated Power Systems Area, refer to Section 5.2.5 for setup instructions.

4. Push the SYSTEMS CHECK button (see Figure 5.2.2.1-1 for configuration) and verify that:

   1. The display reads 18.88.

   2. The RECEPTACLE CHECK neons read O K.

      NOTE: The receptacle test is invalid when testing in an Isolated Power System (IPS) area. An explanation is contained in Section 5.2.5: Receptacle TesTesting.

   3. All status indicators are OFF.

   4. The OUTLET POWER light is ON (with polarity switch in NORM).

      NOTE: If any of the above do not occur, refer to Section 5.2.2.2: Sytems Check — Problem Analysis.

   5. Plug the line cord of the device under test into the Model 501 receptacle.

   6. If the device has ECG leads, perform the following test prior to attaching these leads:

      1. Push ECG LEAD LEAKAGE button.

      2. Push ECG LEAD ISOLATION button.

         WARNING: The Universal ECG Jacks have 120 V through 300 K ohms applied when the ECG LEAD ISOLATION button is pushed.

         Do not touch the jacks during measurement since current of up to 50 *u*A can pass through the ECG jacks.

      3. Record the reading on the display (which should be between 1.0 and 10.0 *u*A) on the inspection form as the Isolation Factor. This reading should be subtracted from the ECG lead isolation measurements which will be made in Section 6.6.

7. If there are ECG leads, attach them to the universal ECG jacks by snapping them onto the top of the jack or by sliding the pins into the holes and screwing down the adapter nut (refer to Figure 5.2.4.1-1).

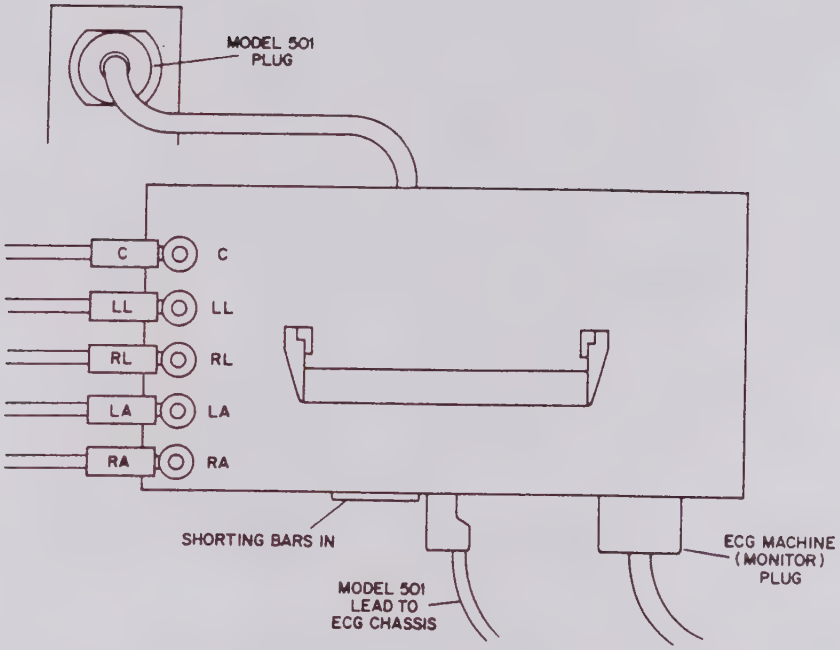

Figure 5.2.5.1-1. ECG Lead Testing

8. Attach the large clamp securely to a screw or other bare metal on the device's chassis.

5.2.4.2 Chassis Leakage Measurement

1. Push the Chassis Leakage button as shown in Figure 5.2.2.1-1.
2. The display indicates leakage in either microamps or millivolts. Take readings in each of the following power configurations:
    1. normal polarity — ground,
    2. reversed polarity — ground,
    3. reversed polarity — no ground,* and
    4. normal polarity — no ground*.

    * If the DANGER light is activated, place the polarity switch on center OFF position. Unplug the device, properly tag and remove for repair.

5.2.4.3 Ground-wire Resistance Measurement

1. Place the POLARITY SWITCH in the center OFF position.

2. Push the GRD WIRE RESISTANCE button.

3. The digital meter reading indicates the resistance in ohms. Bend and manipulate the power cord of the device at the plug and grommet to see if there is any intermittent reading. If the meter reads overrange, the ground wire may be broken, or the device may be double insulated. Check the manufacturer's literature to determine if the device is double insulated and the ground wire resistance cannot be measured. Record this information on the inspection form.

   If the device is not double insulated and the Model 501 reads OVERRANGE, the device is defective. Record the reading and tag accordingly.

5.2.4.4 ECG Lead Leakage Measurement

1. Push the ECG LEAD LLEAKAGE button.

2. Rotate the ECG LEAD SELECTOR switch to each position. Record the highest reading and the lead selected in each of the following power configurations:

   1. normal polarity — ground,

   2. reversed polarity — ground,
   3. reversed polarity — no ground, and

   4. normal polarity — no ground.

   NOTE: The ECG MACHINE SELECTOR switch may be on any lead for all ECG Lead Leakage and Isolation Tests.

   NOTE: If the DANGER light is activated, put the polarity switch in the center OFF position, disconnect the device and label accordingly. Discontinue testing.

5.2.4.5 ECG Lead Isolation Measurement

WARNING

During this test sequence, there are 120 V through 300K ohms applied to the universal ECG jacks. Do not touch these jacks when the LEAD ISOLATION button is pushed.

1. Push the ECG LEAD LEAKAGE button.

2. Put the polarity switch on NORM.

3. Put the ground switch on GROUND. (The ground switch is on GROUND to ensure maximum leaskage reading.

4. Put the polarity switch on RL.

5. Push the ECG LEAD ISOLATION button.

   Record the reading minus the Model 501 Isolation Factor measured in the setup procedure of Section 5.2.4.1, Step 6.

   If the Model 501 reads in excess of 300 *u*A, the ECG unit may not be isolated. Discontinue this test and refer to the ECG Manual to determine isolation. Label the ECG unit accordingly (either "not isolated" or "defective").

6. Rotate the ECG selector to the next ECG lead and respect Step 5.

   It is not necessary to record inter-lead isolation values.

5.2.4.6 AAMI Reading Comparison

The standard for ECG isolation according to the Association for the Advancement of Medical Instrumentation is 20 *u*A for ECG leads using 120 V through a 120K ohms limiting resistor. The Model 501 uses a 300K ohms limiting resistor to provide operator safety. This results in different readings than those provided by the AAMI recommended technique. The isolation test current according to AAMI can be calculated from the current measured with the Model 501. Table 5.2.4.6-1 is also provided following the mathematical derivation with equivalent AAMI readings.

$$I_{501} = I_m - I_f \qquad \text{(Equation 1)}$$

where:

I_{501} = Model 501 isolation leakage current

I_m = meter reading during isolation testing

I_f = isolation factor measured with no leads attached.

The following equation is used to calculate the values given in Table 5.2.4.6-1:

$$I_{AAMI} = \frac{V_{LA} \times I_{501}}{V_{LT} - I_{501}(1.8 \times 10^5)} \qquad \text{(Equation 2)}$$

where:

V_{LA} = AAMI test voltage (120 V)

I_{501} = Model 501 isolation leakage current calculated from Equation 1

V_{LT} = line voltage on which the Model 501 is used

1.8×10^5 = 300K ohm Bio-Tek current limiting resistor minus 120K ohm AAMI current limiting resistor.

SAMPLE CALULATION OF AAMI VALUE FROM MODEL 501 READING

The Model 501 is used with a line voltage of 120 V (V_{LT}). When the LEAD ISOLATION button is pushed and no leads are attached to the Model 501, the meter reads 5.0 *u*A (I_f) and when leads are attached, the meter reads 15.0 *u*A (I_m). By using Equation 1, the Model 510 isolation leakage current is calculated as:

$$I_{501} = 15.0 - 5.0 = 10.0\ uA = 1 \times 10^{-5} \quad .$$

Substituting this value into Equation 2, the I_{AAMI} value can be calculated:

$$I_{AAMI} = \frac{(120) \times (1 \times 10^{-5}}{120 - (1.8 \times 10^5) \times (1 \times 10^{-5})}$$

$$I_{AAMI} = \frac{120 \times 10^{-5}}{118.2}$$

$$= 1.015 \times 10_{-5}$$

$$= 10.1\ uA \quad .$$

Table 5.2.4.6-1. AAMI Reading Comparison

I_{501} at 120 V	I_{AAMI}
10.0	10.0
15.0	15.4
20.0	20.6
30.0	31.4
40.0	42.6
50.0	54.1
60.0	66.0
70.0	78.2
80.0	90.9
90.0	104.0
100.00	118.0
120.0	146.0
140.0	177.0
160.0	210.0
180.0	240.0

NOTE: In the range of importance, the differences are less than 5% which is within realistic measurement accuracies. I_{501} and I_{AAMI} can be considered equal below 30 uA.

5.2.5 Testing Portable Devices Used in Isolated Power Areas

It is recommended that devices used in areas with isolated power systems be tested in areas with a grounded (conventional) power system. The isolated power system (IPS) can decrease leakage current values substantially. In addition, leakage current standards are defined for grounded power system operation.

Testing can be done either outside or inside the IPS area. Section 5.2.5.1 describes testing the devices using a grounded power system and Section 5.2.5.2 describes testing in the IPS area.

The optional adapter described in Section 2.4 are used to adapt the IPS special power connectors for use with the Model 501.

5.2.5.1 Testing Isolated Power System Devices on a Grounded Power System

1. Remove the device under test to an area with grounded referenced power.
2. Plug the device into an adapter cord with a female explosion-proof receptacle on one end of the adapter cord. Connect the other end of the adapter cord to the receptacle on the front panel of the Model 501.
3. Plug the Model 501 line cord into a wall receptacle.
4. The device can now be tested in accordance with Section 6.

5.2.5.2 Testing IPS Devices in the IPS Area

1. Connect the female explosion-proof receptacle of an adapter cord to the male plug of the device under test.
2. Plug the other end of the adapter cord into the Model 501 test receptacle.
3. Plug a male explosion-proof plug from an adapter cord into a receptacle in the IPS area.
4. Plug the line cord of the Model 501 into the female receptacle of the adapter cord of Step 3.
5. Proceed as instructed in Section 6.

5.2.6 Testing Permanently Wired Devices

The testing of permanently wired devices can be carried out only with the device either ON or OFF. (this is in contrast with portable units that can plug into the Model 501 front panel receptacle and have the receptacle conditions varied by Model 501 front panel switching).

5.2.6.1 Single-lead Setup

1. Single-lead measurement (as shown in Figure 5.2.3.3-1):

    1. Place one shorting bar between the top green banana jack and the top black banana jack.

    2. Place the other shorting bar between the bottom green and black banana jack.

    3. Connect the dual plug of the red lead to the two jacks (permanently wired devices).

        NOTE: These shorting bars connect one side of the measuring system to earth ground during chassis leakage measurements and to the Model 501 receptacle ground pin during ground-wire resistance measurements.

2. Attach the large clamp to the single red banana plug on the lead.

3. Plug the Model 501 line cord into a receptacle.

    NOTE: If the devices to be tested are located in an Isolated Power System Area, refer to Section 5.2.5.2, Steps 1 through 4, for setup instructions.

4. Push the SYSTEMS CHECK button (as shown in Figure 5.2.2.1-1). Verify that:

    1. The display reads 18.88.

    2. The RECEPTACLE CHECK neons read O K.

        NOTE: The receptacle test is invalid when testing in an IPS area; an explanation is contained in Section 5.2.3: Receptacle Testing.

    3. All status indicators are OFF.

    4. OUTLET POWER light is ON (with polarity switch in NORM).

        If any of the above do not occur, refer to Section 5.2.2.2 for analysis.

    5. Attach red clamp to chassis of device under test.

    6. Push CHASSIS LEAKAGE CURRENT button. Record readings with the device ON and OFF.

    7. Push GRD WIRE RESISTANCE button. Record reading in ohms.

    8. If the device has ECG leads, continue to Steps 9 through 18.

9. With no ECG leads connected, push the ECG LEAD LEAKAGE button.

10. Push the ECG LEAD ISOLATION button.

    WARNING: There is 120 V on the universal ECG jacks during this test. Do not contact the jacks while the lead isolation button is depressed. Up to 500 *u*A of leakage current may flow through the ECG jacks.

11. Record the meter with the ECG selector on RL. This leakage is internal to the Model 501 and should be subtracted from isolation readings taken in Step 18.

12. Connect the ECG leads to the universal adapters by either snapping them on the top or sliding them in the hole and screwing them down.

13. Push the ECG ISOLATION TEST button with the ECG selector on RL. If the meter reads over 300 *u*A, the unit is either not isolated or faulty. Read the ECG Service Manual and determine if the unit is isolated. If unit is not isolated, proceed to Step 15. (An isolation test cannot be performed on an un-isolated device.) If the unit is isolated, remove from service and mark for repair. If meter reads less than 300 *u*A, proceed to Step 14.

14. Record the isolation leakage on each lead, with the ECG ISOLATION TEST button pushed. Below 30 *u*A the Model 501 readings can be considered equal to values under AAMI standards. Above 30 *u*A refer to Table 5.2.4.6-1 for conversion to AAMI test values. It is not necessary to record inter-lead isolation values.

15. Record the leakage current from each lead with ECG LEAD LEAKAGE button only pushed.

5.2.7 Dual-lead Measurements (Measurements between Conductive Surfaces)

The Model 501 can measure leakage currents, millivolt potentials, as well as resistances between any two points. These measurements are useful under the following circumstances:

1. Checking ground points in a room for point-to-point resistance and millivolt potentials.

2. Measuring leakage currents and ground-wire resistances from devices with 220 V or 208 V power.

3. Measuring leakage current and ground wire resistances from devices in IPS areas without the use of adapter cords.

4. Making miscellaneous measurements independent of ground.

5.2.7.1 Setup

1. Remove any shorting bars from the Model 501 input jacks as shown in Figure 5.2.7.1-1:

    1. Connect the dual plug of the black lead to the two black jacks.
    2. Connect the dual plug of the red lead to the two red jacks.

2. Connect the appropriate adapters or probes to the other ends of the leads depending on the type of measurement to be made.
3. Press the following buttons for measurements indicated:

BUTTON	MEASUREMENT
Ground-wire Resistance	Resistance (ohms)
Chassis Leakage	Potential Difference (Millivolts)
	Leakage Current (Microamps)

These measurements are relative to the two points that the lead ends contact and are independent of earth ground.

5.2.8 Measuring Leakage Current through the Ground Wire

The Model 501 can measure leakage current through the ground wire, providing a quick way to spot check equipment. The readings obtained are identical to the readings that are obtained in Section 5.2.4.2: Chassis Leakage Measurement, and can only be taken on portable devices that can be connected to the Model 501 receptacle.

It is recommended that this test not be used as routine inspection since chassis leakage from exposed metal is the desired measurement parameter. Also to properly test a device, the ground wire resistance must be measured and to do this requires a lead to be connected to the chassis. The Model 501 is designed to take advantage of a one lead setup to make all measurements; however, for quick spot checks, leakage current through the ground wire can be measured easily.

5.2.8.1 Setup

1. See Figure 5.2.8.1-1 for setup of the Model 501 to measure leakage current through the ground wire.

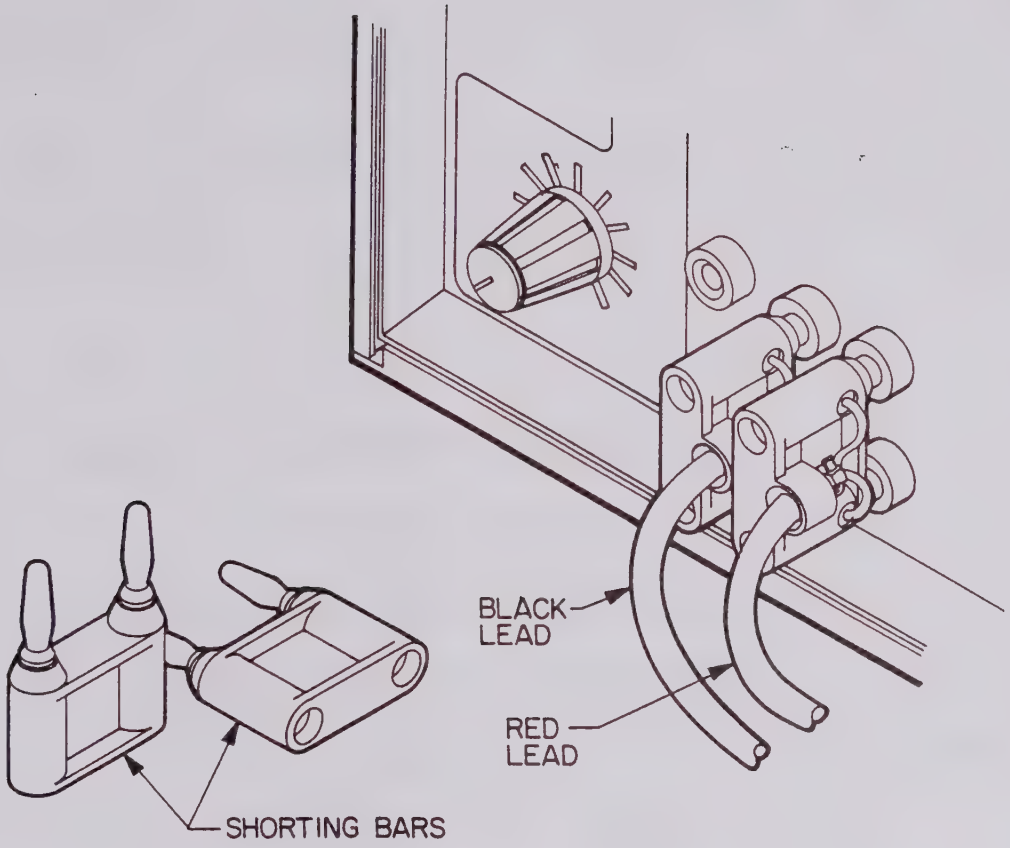

Figure 5.2.7.1-1. Dual-lead Setup (Conductive Surfaces Measurements)

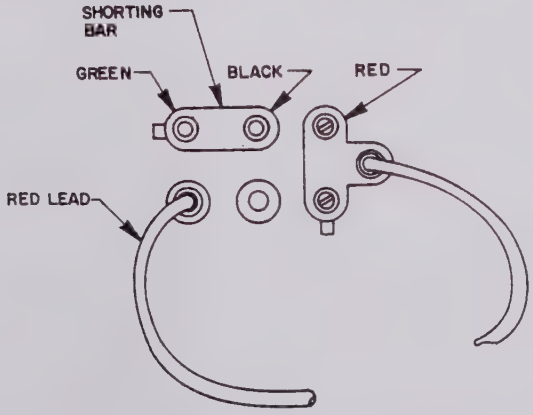

Figure 5.2.8.1-1. Setup for Measuring Leakage Current through the Ground Wire

1. Connect a shorting bar between the top black and top green jacks.

2. Connect the dual banana plug of the red lead to the two red input jacks.

3. Connect the single banana plug of the red lead to the bottom green banana jack.

2. Plug the device to be tested into the Model 501 test receptacle.

5.2.8.2 Measurement

1. Put the ground switch on NO GROUND. This is necessary for any measurement in this section.

2. Push the CHASSIS LEAKAGE button.

3. Change the Model 501 receptacle conditions and take readings with the device ON and OFF with NORMAL and REVERSED polarity.

   CAUTION: If the DANGER light is activated, place the polarity switch in the center OFF position. Unplug the device, properly tag and remove from service.

6 CALIBRATION

We recommend that each Model 501 be recalibrated annually. Calibration instructions this section. If the purchaser does not possess the necessary equipment for proper recalibration, return the Model 501 to Bio-Tek for NBS traceable calibration. Refer to Section 3.3 for shipping information.

6.1 Low Battery Verification

1. Use a variable power supply instead of the battery packs for the initial powering up of the Model 501. Put in about 10.5 VDC.

2. Plug two shorting bars into the two red panel jacks and the two black jacks. Push the GRD WIRE RESISTANCE button.

    1. Make sure the Model 501 is reading 1999 and the overrange light in ON.

    2. Decrease the power supply voltage until the low battery light comes on (around 9.1 — 9.8 V on the DVM).

    3. Keep decreasing the power supply voltage until the 501's overrange light shuts OFF (around 8.4 VDC).

    4. Then increase the power supply voltage back up to 10.5 V.

6.2 Nulling Current Amplifier

1. Unplug the two shorting bars and put in the small shorting bar to short out the two top red and black jacks on the Model 501 (signal input jacks).

2. Put your black lead from the DVM into the ground jack of the 501 (TP 205) set DVM on DCV X 1.

3. Put the red lead from the DVM into TP 202 and push the CHASSIS LEAKAGE button.

4. Adjust R213 to read 0.0000 V on the DVM.

5. Plug the red lead from the DVM into TP 302.

6. Adjust R222 to read 0.0000 V on the DVM.

6.3 Nulling Ohms Amplifier

1. Keep the input shorted on the Model 501 and put the function switch on GRD WIRE RESISTANCE.
2. Put the red lead from DVM into TP 201.
3. Adjust R228 to read 0.0000 V on the DVM.
4. Plug the red lead into TP 203.
5. Adjust R225 to read 0.0000 V on the DVM.

6.4 Chassis Leakage Gain Adjustment

1. Push the CHASSIS LEAKAGE button on the Model 501 and remove the shorting bar from the input jacks.
2. Apply 1.9000 VDC to the signal input jack (red and black).
3. Adjust R219 until the Model 501 display reads 1900.
4. Reverse the polarity of the input power to see if you still read 1900 or ± 0.5%.
5. Apply 0.1900 VDC to the signal input.
6. Adjust R216 until the the Model 501 display reads 190.0.

   NOTE: Signal input must be lowered to less than 0.180 V for the Model 501 low range to be activated.
7. Go through the rest of the DC mV readings and record them on the calibration sheet (including the 10 *u*A reading on DC and AC and also the AC mV readings).

6.5 Systems Check Adjustment

1. Remove power supply from input and push SYSTEMS CHECK.
2. Put the red lead from DVM into TP 204 and the black lead into TP 205.
3. Adjust R211 so the DVM reads 0.1885 V.

   NOTE: The Model 501 should read 18.88.

6.6 Ohms Gain adjustment

1. Connect the two Model 501 leads to signal input and push GRD WIRE RESISTANCE.
2. Connect the Modle 501 leads to a precision 10.11 ohm resistor.
3. Adjust R252 until the Model 501 reads 10.00.
4. Take the rest of the Model 501 ohms readings and record.
5. Put finger nail polish on all pots.

6.7 Final Quality Control

1. Reattach the rear panel assembly (with the serial number tag) and then place the Model 501 into its case for the final calibration.
2. Push the SYSTEM CHECK button to make sure unit is still working.
3. Push GRD WIRE RESISTANCE button and put a 1.00 ohm resistor across the ground and neutral pins of Model 501's cord plug.

   NOTE: The Model 501 should read around 1.20 ohms on the display when the NEUTRAL-TO-GRD RESISTANCE button is pushed.

4. Plug a test receptacle into the wall receptacle and the Modle 501 into the test receptacle as follows:

Norm-GRD = O K lights	Norm-No GRD = O K light
Rev-GRD = O K O-Rev lights	Rev-No GRD = O K light

5. Plug the Model 501 into a wall receptacle and a test receptacle into the Model 501's receptacle. While leaving the test receptacle's toggle switch on NORM-GRD the test reeptacle's lights should read the following when the Modle 501's toggles are switched:

Norm-GRD = O K lights	Norm-No GRD = O K light
Rev-GRD = O K O-Rev lights	Rev-No GRD = O K light

6. Leave the test receptacle plugged into the Model 501 and the Model 501 plugged into the wall.

1. Short out the green and black jacks on the Model 501 and plug in a red lead from the ground jack on the test receptacle to the red signal input jack.

2. Push the CHASSIS LEAKAGE button and switch the Model 501 toggle switch to NO GRD, the 01 display should read around 250 mV.

NOTE: Leave the Model 501 plugged into the wall for the following checks and unplug the test receptacle from the Model 501's receptacle. Turn the Model 501 OFF. The BATTERY CHARGING light should be ON.

7. Push ECG LEAD LEAKAGE button and the LEAD ISOLATION button, while going through the RA, LA, RL, LL and C positions of the rotary switch.

   1. Observe the Model 501 display reading (around 2.0).

   2. Turn the rotary switch back to RA and plug a 1 Mohm resistor (the blue wire) between the **RA** jack (on the top of the case) and the Ground jack (on the back of the panel).

   3. Observe the reading on the Model 501 when the LEAD ISOLATION button is pushed (around 97.0).

8. Leave the Microamps-Millivolts button pushed and put 1.0 V across the RA jack and ground.

   1. Observe the display reading (should read the same thing you recorded during calibration).

   2. Check the OHMS button to make sure it still is in calibration specifications.

9. Turn the Model 501 OFF.

7 SCHEMATICS, COMPONENT LAYOUTS, AND PARTS LISTS

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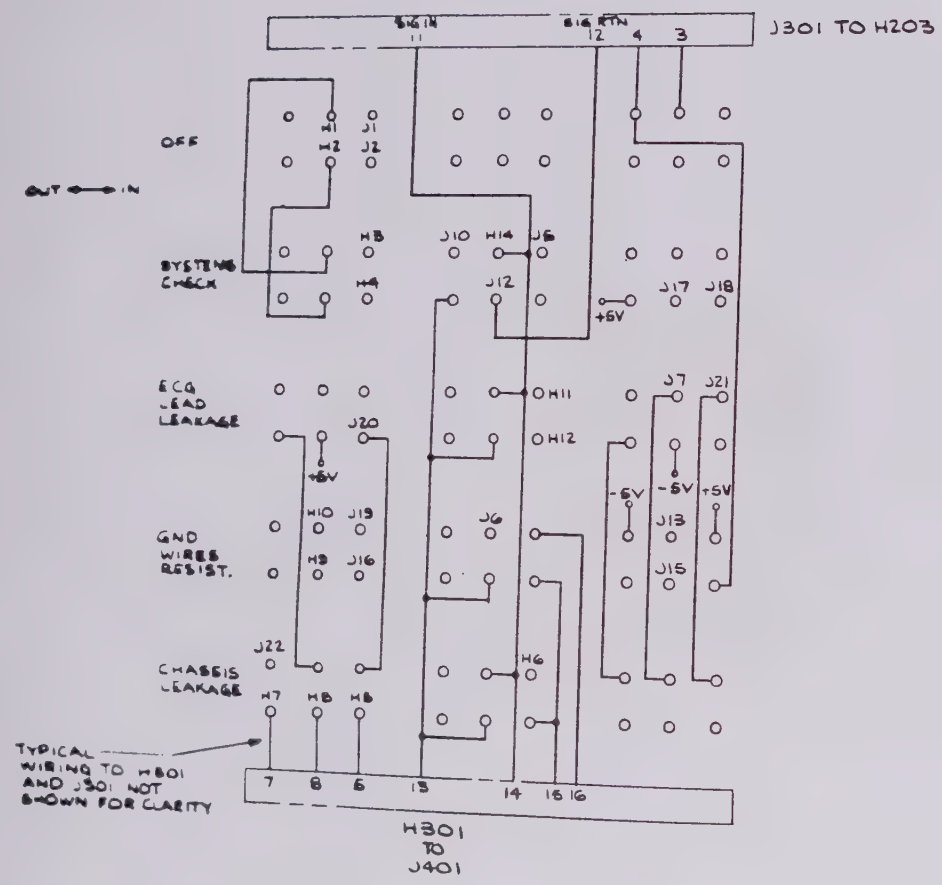
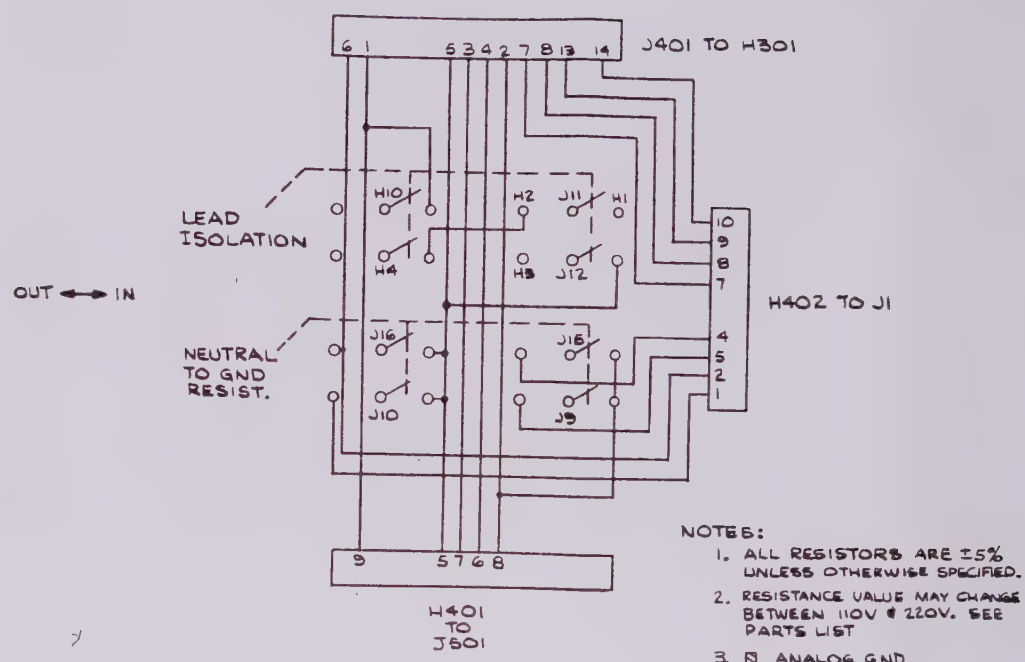
300 SERIES
TOP & BOTTOM
PUSH BUTTON SWITCH
P.C. BOARD



400 SERIES
MOMENTARY SWITCH
P.C. BOARD



NOTES:
1. ALL RESISTORS ARE ±5% UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUE MAY CHANGE BETWEEN 110V & 220V. SEE PARTS LIST
3. ANALOG GND
   DIGITAL GND

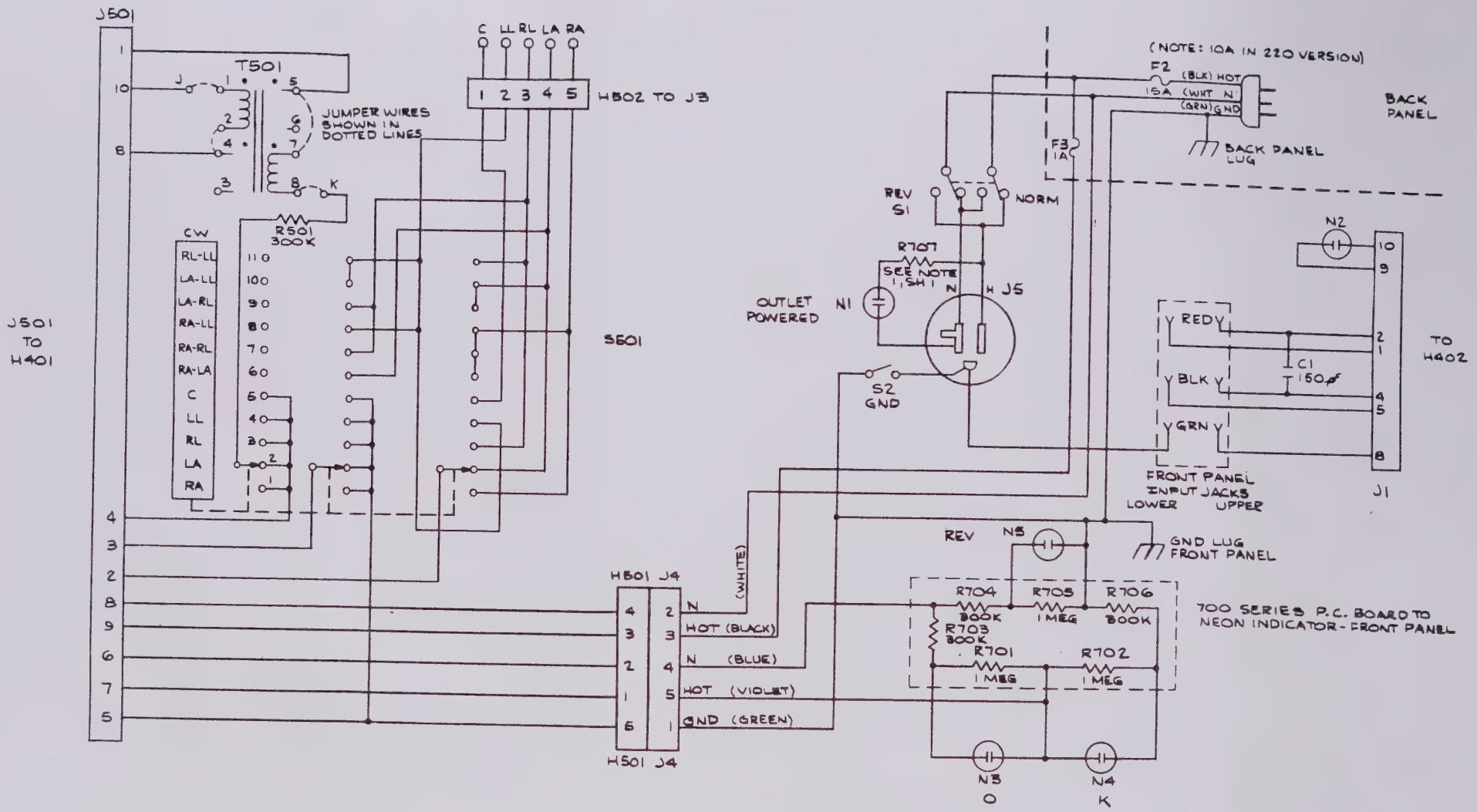
BIO-TEK INSTRUMENTS, INC.
HIGHLAND PARK, BOX 998
WINOOSKI, VT 05404-0998

REV	DESCRIPTION	DATE/BY
C	Change Value of R104 ECO 3404	6/4/86 MS
B	REV PER ECO 000132	8 Oct 81 JB
A	RELEASE TO PRODUCTION PER ECO 000176	1/27/82 JB

SCALE NONE | DRAWN | CHK'D | SHEET 1 OF 3

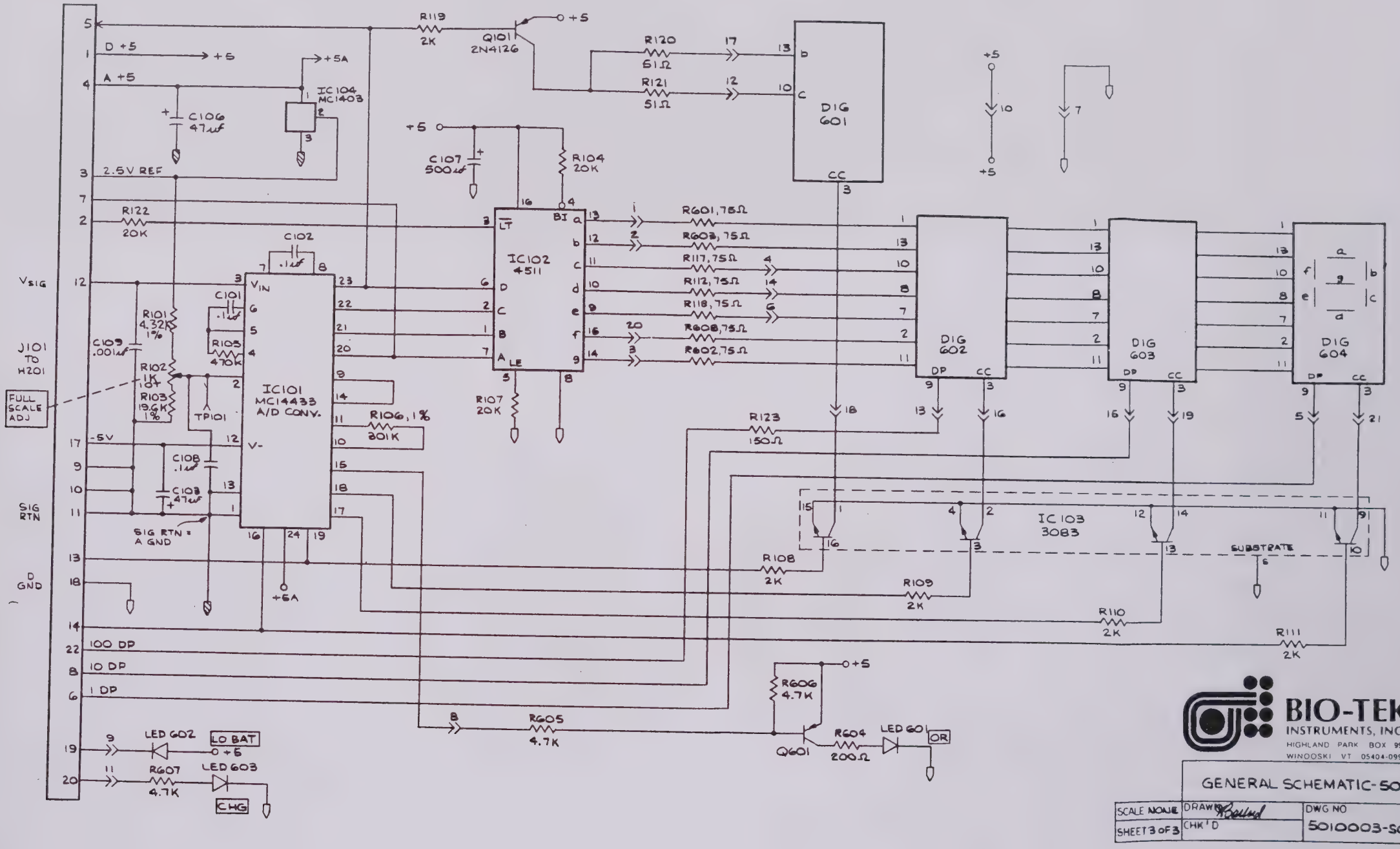
GENERAL SCHEMATIC-501

DWG NO 5010003-6C



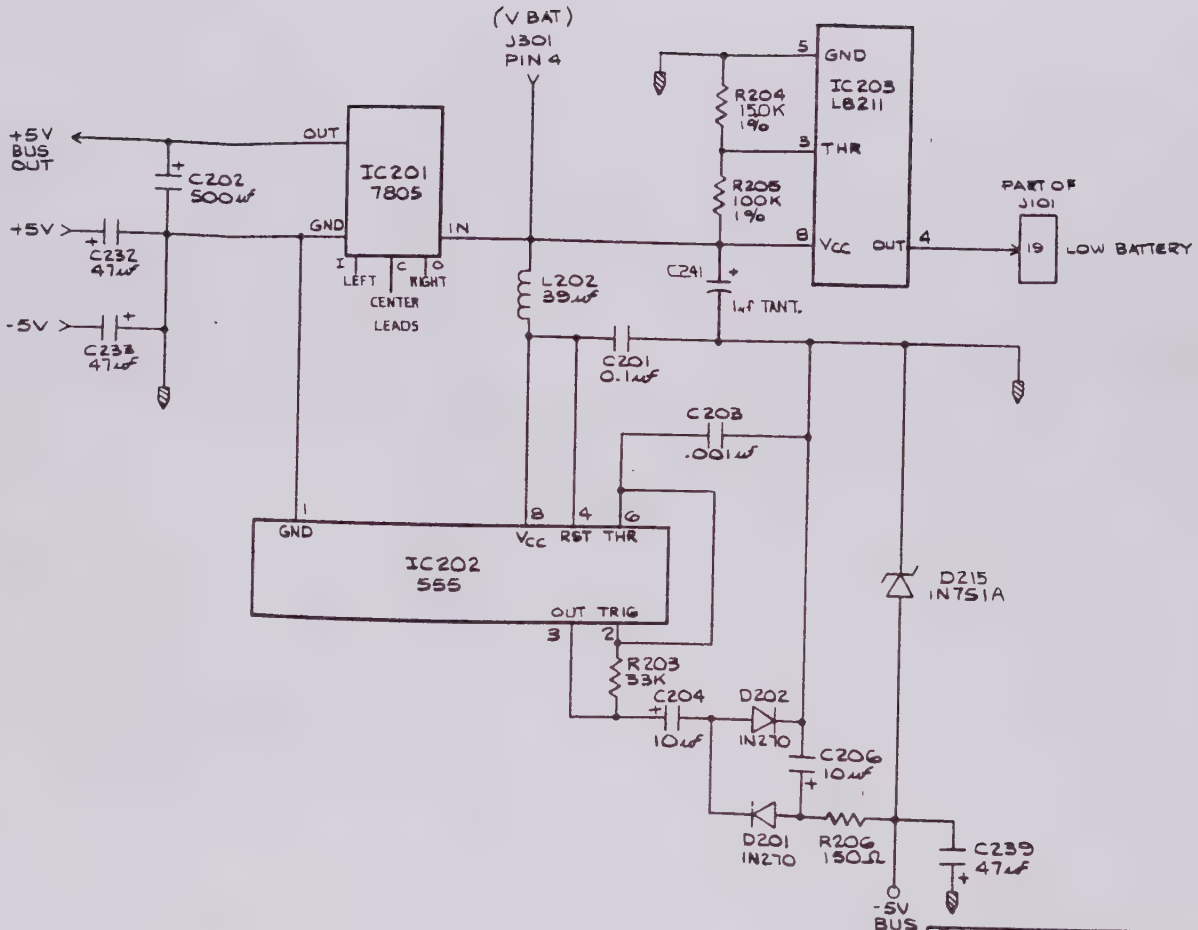
BIO-TEK INSTRUMENTS, INC.
HIGHLAND PARK BOX 998
WINOOSKI, VT 05404-0998

	GENERAL SCHEMATIC - 601	
SCALE NONE	DRAWN Ballard	DWG NO
SHEET 2 OF 3	CHK'D	5010003-SC



BIO-TEK INSTRUMENTS, INC.
HIGHLAND PARK BOX 998
WINOOSKI VT 05404-0998

GENERAL SCHEMATIC-501		
SCALE NONE	DRAWN	DWG NO
SHEET 3 OF 3	CHK'D	5010003-SC



NOTES:

1. ALL RESISTORS IN OHMS, ±5% UNLESS OTHERWISE SPECIFIED.
2. TO ELIMINATE NOISE THE +5 VOLT BUS AND GROUND BUS TO LOW LEVEL ANALOG SIGNAL COMPONENTS ARE RUN SEPARATELY AND INDICATED SCHEMATICALLY BY A +5V AND ⏚.
3. ⏚ - ANALOG GND

   ⏚ - DIGITAL GND

SEE SEPARATE PARTS LIST

BIO-TEK INSTRUMENTS, INC.
HIGHLAND PARK BOX 188
WINOOSKI VT 05404-0694

REV	DESCRIPTION	BY / DATE
G	CHANGE ADDRESS, RE-INK NOTES	9-10-86
F	R204 from 150K to 147K 1% ECO 1339	6-7-91
E	REV PER ECO 680	7-14-90
D	Rev Per ECO 593	9-15-89
C	Rev PER ECO 436	5-24-89
B	RELEASE TO PRODUCTION PER ECO 000176	1-20-88
A	REV PER ECO 000151	11-24-87

SCALE NONE

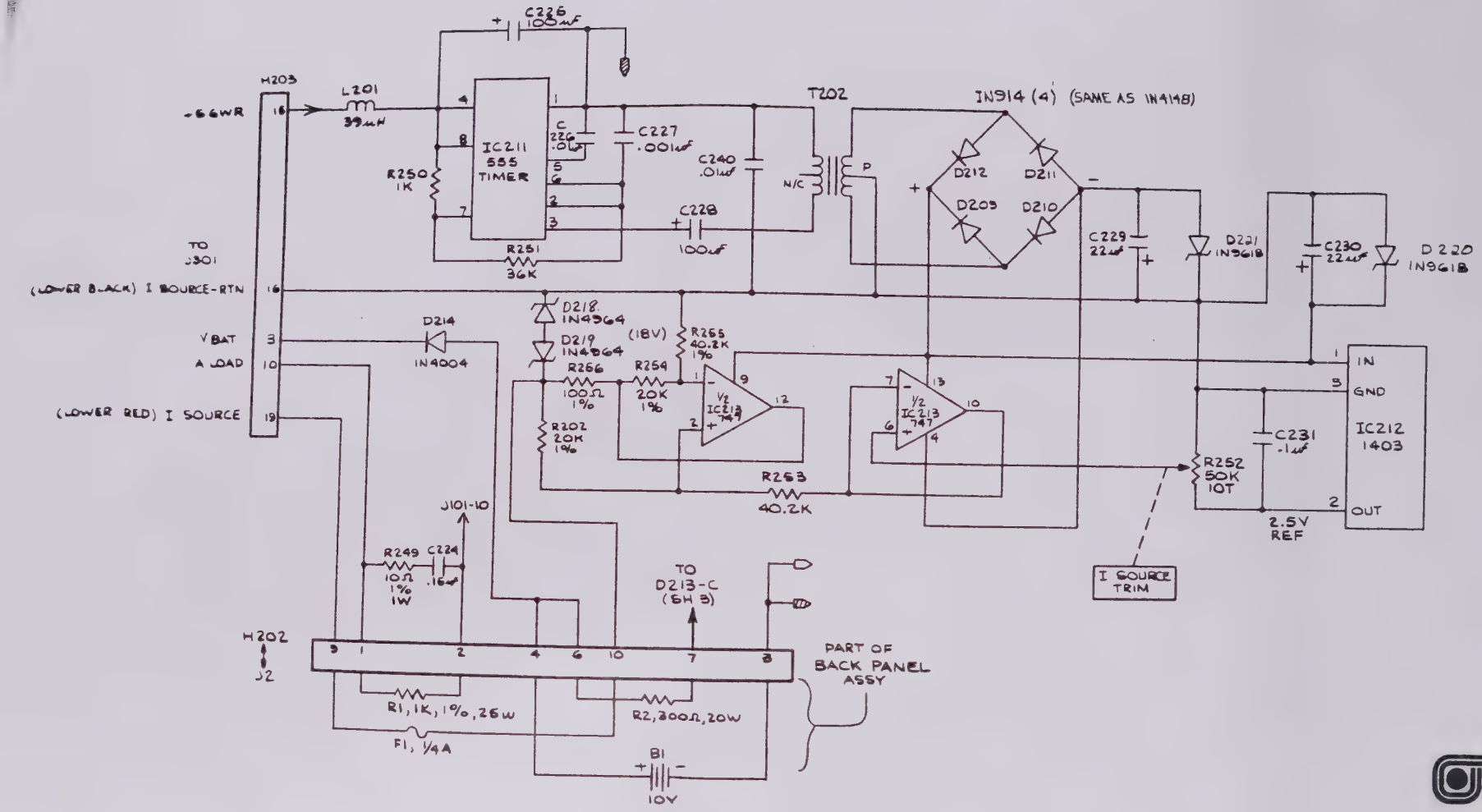
SHEET 1 OF 4

200 SERIES P.C. BOARD-501 SCHEMATIC

DRAWN 13 Aug 91

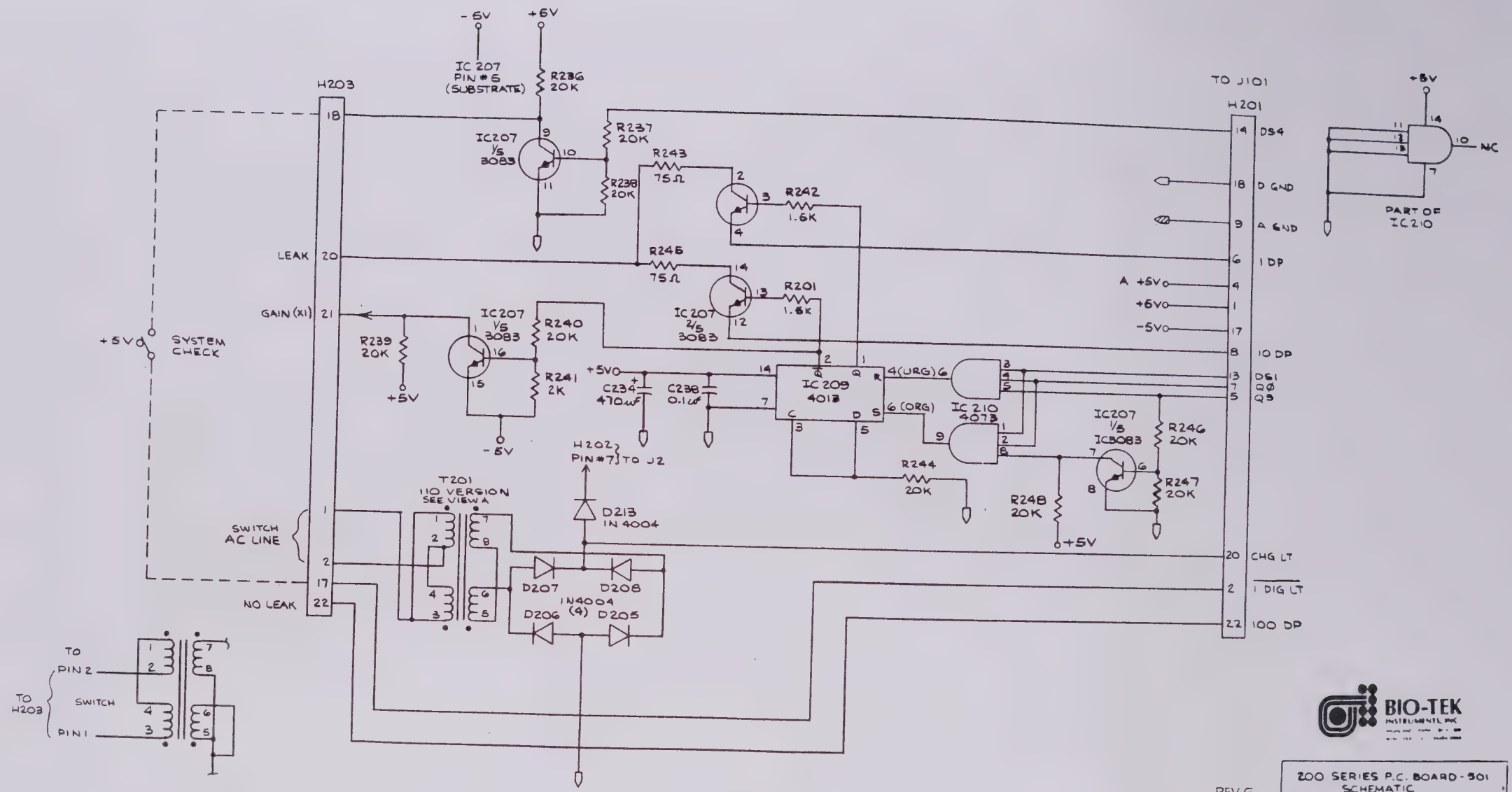
CHK'D

DWG NO 5010002-5C



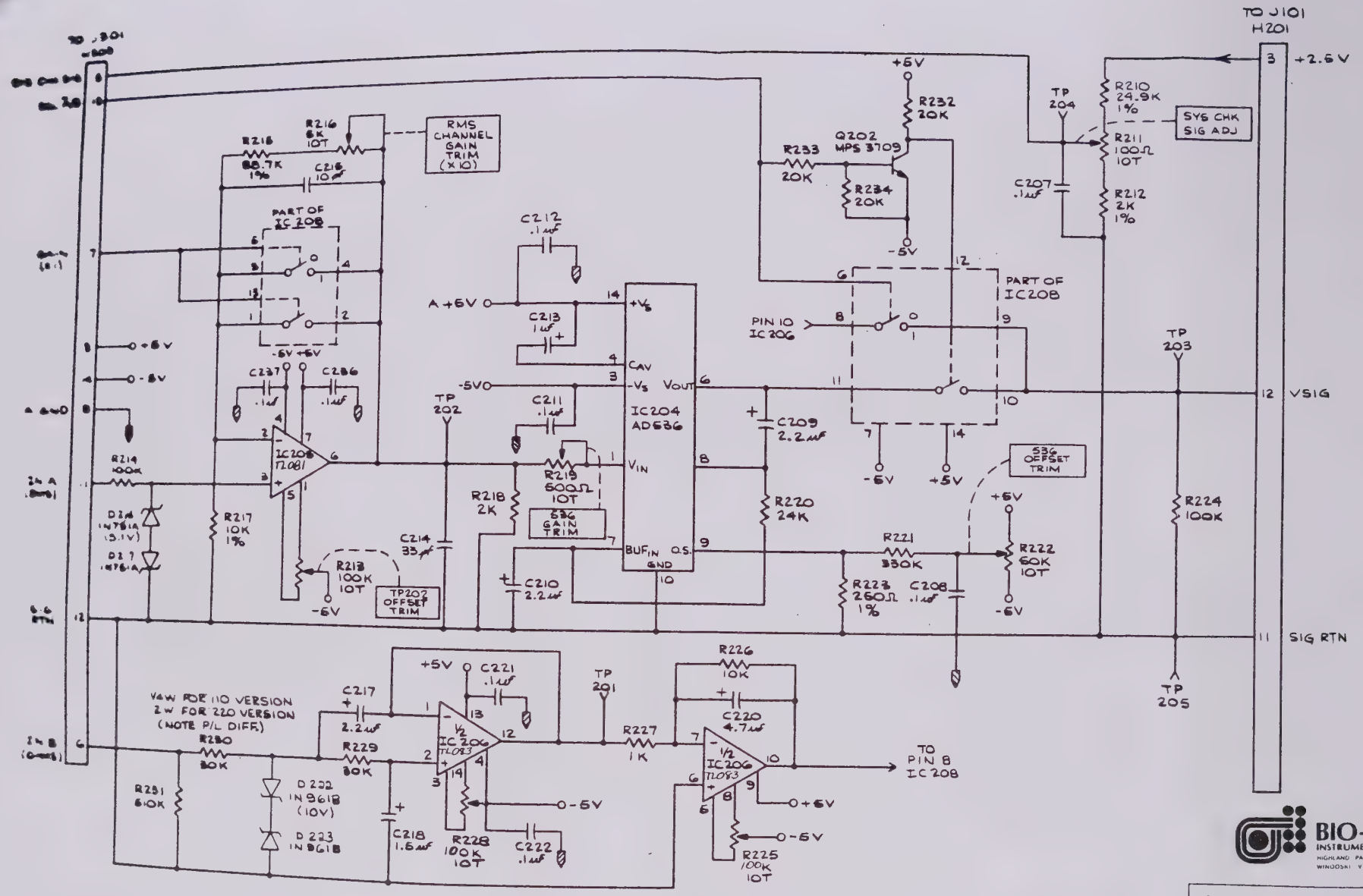
BIO-TEK
INSTRUMENTS, INC.
HIGHLAND PARK, BOX
WINOOSKI, VT 05404 0068

REV G	200 SERIES P.C. BOARD - 501 SCHEMATIC	
SCALE NONE	DRAWN	DWG NO
SHEET 2 OF 4	CHK'D	5010002-6C

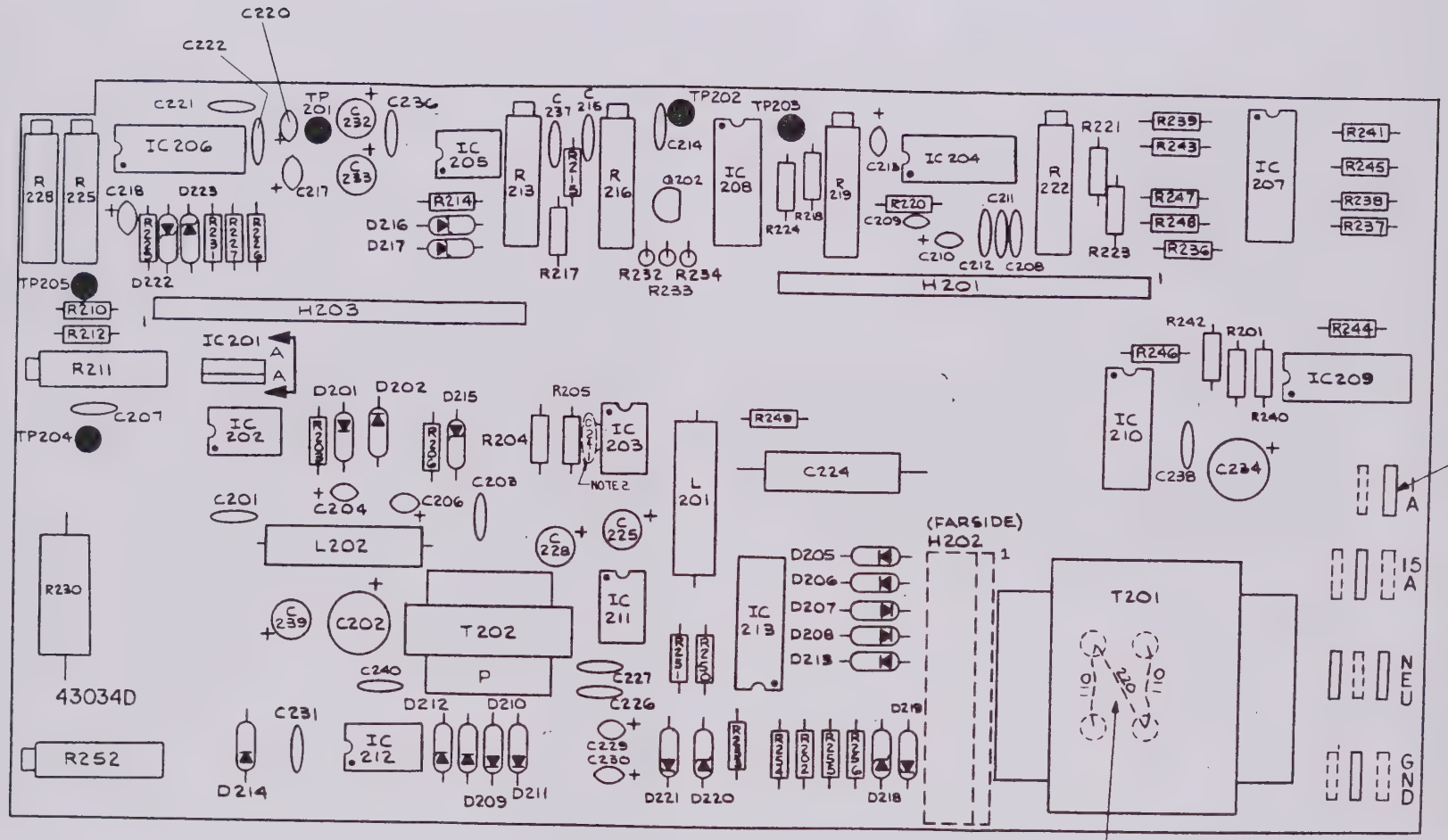


BIO-TEK INSTRUMENTS INC

REV G	200 SERIES P.C. BOARD - 301 SCHEMATIC	
SCALE NONE	DRAWN Jallard	DWG NO 5010002-SC
SHEET 3 OF 4	CHK'D	



REV G	200 SERIES P.C. BOARD - 601 SCHEMATIC	
SCALE NONE	DRAWN Ballard	DWG NO
SHEET 4 OF 4	CHK'D	5010002-6C

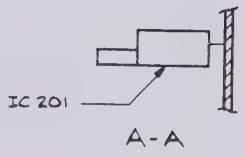


NOTES:

1. DESIGNATES PIN1
2. C241 IS MOUNTED ON NON-COMPONENT SIDE OF PCB. THE + LEAD TO PIN 8 OF IC203, AND THE OTHER LEAD TO PIN 5 OF IC203. MOUNT AS CLOSE TO PCB AS POSSIBLE.

SEE SEPARATE PARTS LIST

COMPONENT SIDE

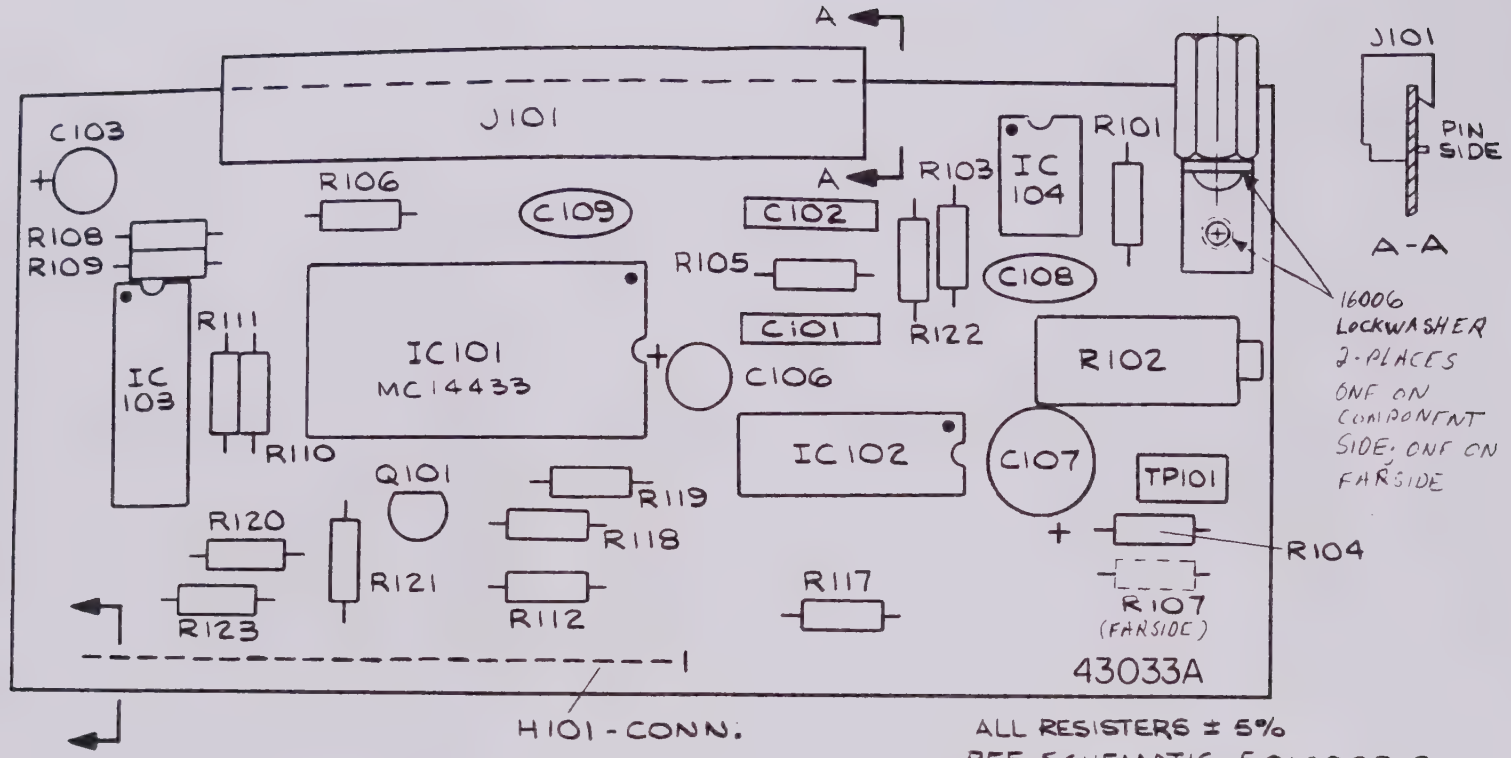


REV	DESCRIPTION	DATE/BY
F	REV PER ECO 000373	7/19/93 SP
E	REV PER ECO 000089	7/6/92 SP
D	REV PER ECO 000020	2/4/92 PL
C	REV PER ECO 000290	5/24/91 PB
B	RELEASE TO PRODUCTION PER ECO 000176	1/23/91 PB
A	REV PER ECO 000181	11/26/90 PB
H	ADD C241 & NOTE 2	9-11-86 JR
G	Delete C235 ECO 543	7/16/85 SP

BIO-TEK INSTRUMENTS, INC

MAIN P.C. BOARD
COMPONENT LAYOUT

SCALE NONE | SHEET 1 OF 1 | DRAWN [illegible] 5/28/91 | CHK'D | DWG NO 5010002-AS

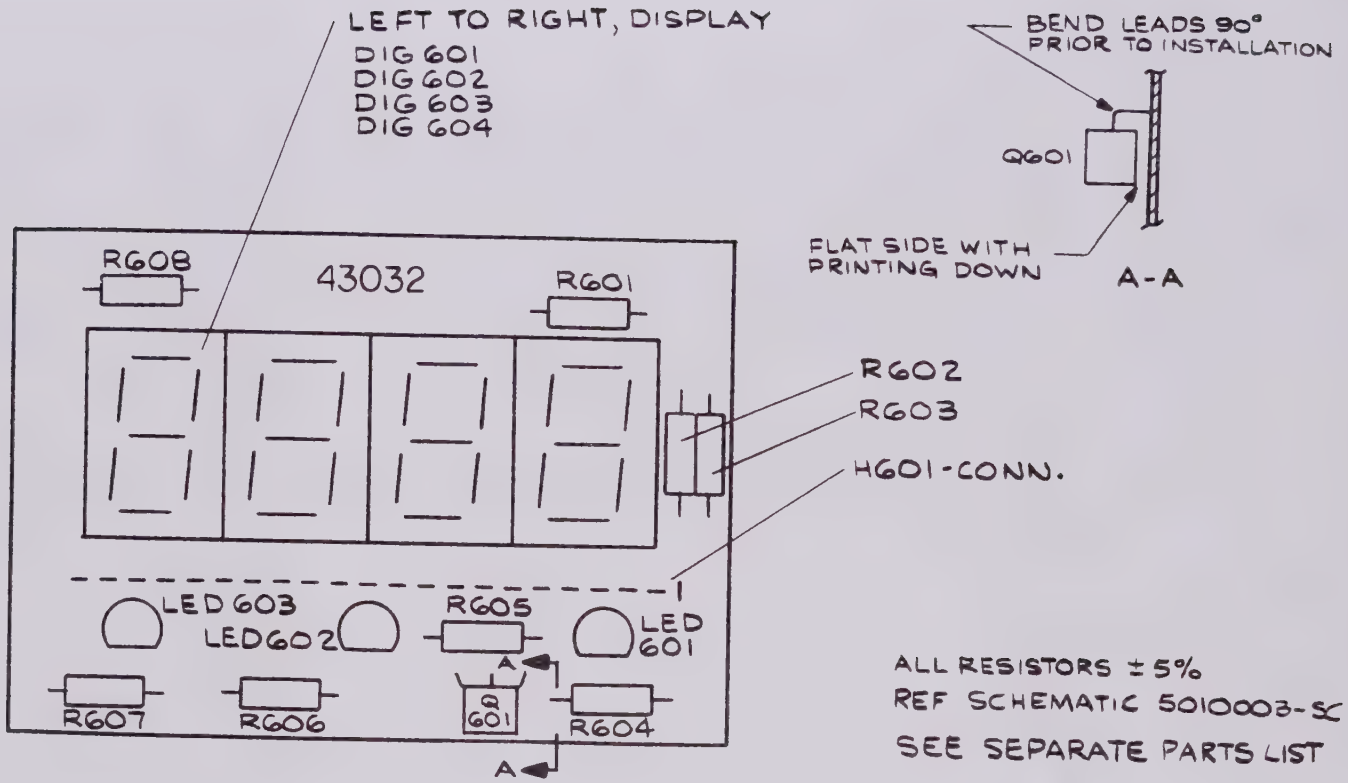


BIO-TEK INSTRUMENTS, INC.
HIGHLAND PARK, BOX 998
WINOOSKI, VT. 05404-0998

REV	DESCRIPTION	DATE/BY		
D	Change 16002 to 16006 ECO 295-7	2/6/86 MS		
C	REV PER ECO 473	10/13/85 SP		
B	REV PER ECO 216	3/13/85 SP		
A	RELEASE TO PRODUCTION PER ECO 000176	MS 11/27/82	SCALE NONE	DRAWN JS Ballard
			SHEET 1 OF 2	CHK'D

100 SERIES P.C. BOARD - 501 - COMPONENT LAYOUT

DWG NO 5010004-AS



ALL RESISTORS ± 5%
REF SCHEMATIC 5010003-SC
SEE SEPARATE PARTS LIST

COMPONENT SIDE

BIO-TEK INSTRUMENTS, INC.
HIGHLAND PARK BOX 998
WINOOSKI, VT 05404-0998

Rev D

REV	DESCRIPTION	DATE/BY	SCALE NONE	CHK'D
B	REV PER ECO 000216	3/31/92		
A	RELEASE TO PRODUCTION PER ECO 000176	1/27/89	SHEET 2 OF 2	DRAWN Holland 8Oct91

600 SERIES P.C. BOARD - 501
COMPONENT LAYOUT

DWG NO 5010004-AS

KITTING LIST

5010002 501 PCB ASBY MAIN RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL ***	J 5-23-84	99	.00	.00	
21003	DIODE 1N4004 1A 200V	D213,214	2	2.00	2.00	
21003	DIODE 1N4004 1A 200V	D205-208	2	4.00	4.00	
21004	DIODE 1N4148 SIGNAL	D209-212	2	4.00	4.00	
21005	DIODE 1N270 GERMANIUM SIG	D201,202	2	2.00	2.00	
22001	DIODE 1N5240B ZENER 10V	D220-223	6	4.00	4.00	
22017	DIODE 1N5231B ZENER 5.1V	D215-217	6	3.00	3.00	
22031	DIODE 1N4964 ZENER 18V	D218,219	6	2.00	2.00	
23005	IC 555 TIMER MINIDIP PLST	IC202,211	8	2.00	2.00	
23016	OP AMP 747	IC213	8	1.00	1.00	
23017	VOLT REG +5V 7805	IC201	8	1.00	1.00	
23018	VOLT DET 8211	IC203	8	1.00	1.00	
23019	TRANSISTOR ARRY 3083/2083	IC207	8	1.00	1.00	
23035	OP AMP TL081 HI BANDWIDTH	IC205	8	1.00	1.00	
23036	OP AMP TL083 DUAL	IC206	8	1.00	1.00	
25001	IC 4066 QUAD SWITCH	IC208	8	1.00	1.00	
25004	IC 4073 AND 3-IN	IC210	6	1.00	1.00	
25008	IC 4013 FLIP-FLOP DUAL	IC209	8	1.00	1.00	
25009	IC 536 RMS-TO-DC CONVERTR	IC204	8	1.00	1.00	
26002	TRANSISTOR 2N4123 SIG NPN	Q202	8	1.00	1.00	

KITTING LIST

5010002 501 PCB ASBY MAIN RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
28004	VOLT REF 2.5	IC212	8	1.00	1.00	
31102	RES 1.0K OHM 5% 1/4W	R227,250	2	2.00	2.00	
31103	RES 10.0K OHM 5% 1/4W	R226	2	1.00	1.00	
31104	RES 100.0K OHM 5% 1/4W	R214,224	2	2.00	2.00	
31151	RES 150.0 OHM 5% 1/4W	R206	2	1.00	1.00	
31152	RES 1.5K OHM 5% 1/4W	R201,242	2	2.00	2.00	
31202	RES 2.0K OHM 5% 1/4W	R218,241	2	2.00	2.00	
31203	RES 20.0K OHM 5% 1/4W	R232-234	2	3.00	3.00	
31203	RES 20.0K OHM 5% 1/4W	R246-248	2	3.00	3.00	
31203	RES 20.0K OHM 5% 1/4W	R236-240,244	2	6.00	6.00	
31243	RES 24.0K OHM 5% 1/4W	R220	2	1.00	1.00	
31303	RES 30.0K OHM 5% 1/4W	R229	2	1.00	1.00	
31333	RES 33.0K OHM 5% 1/4W	R203	2	1.00	1.00	
31334	RES 330.0K OHM 5% 1/4W	R221	2	1.00	1.00	
31363	RES 36.0K OHM 5% 1/4W	R251	2	1.00	1.00	
31514	RES 510.0K OHM 5% 1/4W	R231	2	1.00	1.00	
31750	RES 75.0 OHM 5% 1/4W	R243,245	2	2.00	2.00	
32019	RES 40.20K OHM 1% 1/4W	R253,255	2	2.00	2.00	
32030	RES 100.00K OHM 1% 1/4W	R205	2	1.00	1.00	
32042	RES 10.00K OHM 1% 1/4W	R217	2	1.00	1.00	

KITTING LIST

5010002 501 PCB ASBY MAIN RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
32044	RES 20.00K OHM 1% 1/4W	R202,254	2	2.00	2.00	
32045	RES 24.90K OHM 1% 1/4W	R210	2	1.00	1.00	
32077	RES 88.70K OHM 1% 1/4W	R215	2	1.00	1.00	
32085	RES 15.00K OHM 1% 1/4W	R204	2	1.00	1.00	
32100	RES 100.00 OHM 1% 1/4W	R256	2	1.00	1.00	
32111	RES 249.00 OHM 1% 1/4W	R223	2	1.00	1.00	
32112	RES 2.00K OHM 1% 1/4W	R212	2	1.00	1.00	
33005	RES 10.00 OHM 1% 1W MF	R249	8	1.00	1.00	
33050	RES 30.00K OHM 5% 2W	R230	2	1.00	1.00	
34002	TRIMPOT 100 OHM, 10T	R211	6	1.00	1.00	
34006	TRIMPOT 50K, 10T	R222,252	6	2.00	2.00	
34007	TRIMPOT 100K, 10T	R213,225,228	6	3.00	3.00	
34008	TRIMPOT 5K, 10T	R216	6	1.00	1.00	
34009	TRIMPOT 500 OHM, 10T	R219	6	1.00	1.00	
42038	HEDR 22-P .100 GOLD	H201,203	6	2.00	2.00	
42039	HEDR 10-P .156 LOK		6	1.00	1.00	
42063	HEDR .250 MTAB		2	11.00	11.00	
43034	PCB 200-SERIES 501		8	1.00	1.00	
44092	TAPE FOAM MTG 1.5"x.5"	1.5"PC 67008	6	1.00	1.00	
44093	CABLE PROTECTOR ECG-II	7x1.75 67007	2	1.00	1.00	

KITTING LIST

5010002 501 PCB ASBY MAIN RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
45014	TERM PCB	TP201-205	2	5.00	5.00	
61005	TRANSF AUDIO	T202	8	1.00	1.00	
61006	TRANSF 120/220 34V CT	T201	8	1.00	1.00	
63001	INDUCTOR 39uH	L201,202	8	2.00	2.00	
81005	CAP 47 uF 16V ELEC	C232,233,239	2	3.00	3.00	
81006	CAP 470 uF 10V ELEC	C202,234	8	2.00	2.00	
81007	CAP 100 uF 16V ELEC	C225,228	8	2.00	2.00	
82001	CAP 4.7 uF 10V TANT	C220	8	1.00	1.00	
82003	CAP 10 uF 25V TANT	C204,206	8	2.00	2.00	
82004	CAP 22 uF 15V TANT	C229,230	8	2.00	2.00	
82005	CAP 1 uF 35V TANT	C213,241	8	2.00	2.00	
82006	CAP 2.2 uF 35V TANT	C209,210,217	8	3.00	3.00	
82007	CAP 1.5 uF 25V TANT	C218	8	1.00	1.00	
83001	CAP 33 pF DISC	C214	8	1.00	1.00	
83004	CAP .001 uF 100V DISC	C203,227	2	2.00	2.00	
83007	CAP .01 uF 50V DISC	C226	2	1.00	1.00	
83010	CAP .01 uF 1000V DISC	C240	8	1.00	1.00	
83012	CAP 10 pF 1000V DISC	C215	2	1.00	1.00	
83013	CAP .1 uF 100V DISC	C211,212	8	2.00	2.00	
83019	CAP .1 uF 100V DISC	C201,207,208	8	3.00	3.00	

KITTING LIST

5010002 501 PCB ASBY MAIN RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
83019	CAP .1 uF 100V DISC	C221,222,231	8	3.00	3.00	
83019	CAP .1 uF 100V DISC	C236-238	8	3.00	3.00	
84004	CAP .15 uF 250V FOIL	C224	8	1.00	1.00	

KITTING LIST

5010004 501 PCB ASBY DISPLAY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL ***	I 05-09-86	99	.00	.00	
03004	LED RED	LED601-603	6	3.00	3.00	
04001	DISPLAY 7 SEG. .43"	DIG601-604	6	4.00	4.00	
12019	SCR PAN 4-40x3/16 SS SLOT		2	2.00	2.00	
16006	LKWSHR #4 INT TOOTH SZ		2	2.00	2.00	
23019	TRANSISTOR ARRY 3083/2083	IC103	8	1.00	1.00	
25006	IC 4433 DIG A/D CONVERTER	IC101	8	1.00	1.00	
25007	IC 4511 BCD DRIVE 7SEG LT	IC102	8	1.00	1.00	
26001	TRANSISTOR 2N4126 SIG PNP	Q101,601	8	2.00	2.00	
28004	VOLT REF 2.5	IC104	8	1.00	1.00	
31151	RES 150.0 OHM 5% 1/4W	R123	2	1.00	1.00	
31201	RES 200.0 OHM 5% 1/4W	R604	2	1.00	1.00	
31202	RES 2.0K OHM 5% 1/4W	R108-111,119	2	5.00	5.00	
31203	RES 20.0K OHM 5% 1/4W	R104,107,122	2	3.00	3.00	
31472	RES 4.7K OHM 5% 1/4W	R605-607	2	3.00	3.00	
31474	RES 470.0K OHM 5% 1/4W	R105	2	1.00	1.00	
31510	RES 51.0 OHM 5% 1/4W	R120,121	2	2.00	2.00	
31750	RES 75.0 OHM 5% 1/4W	R112,117,118	2	3.00	3.00	
31750	RES 75.0 OHM 5% 1/4W	R601-603,608	2	4.00	4.00	
32035	RES 301.00K OHM 1% 1/4W	R106	2	1.00	1.00	

KITTING LIST

5010004 501 PCB ASBY DISPLAY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
32114	RES 19.60K OHM 1% 1/4W	R103	2	1.00	1.00	
32135	RES 4.32K OHM 1% 1/4W	R101	2	1.00	1.00	
34004	TRIMPOT 1K, 10T	R102	6	1.00	1.00	
42037	HEDR 22-S .100 RYANG GOLD	J101	12	1.00	1.00	
42068	HEDR 21-P .10 RTANG SINGL	H601	6	1.00	1.00	
43032	PCB 600-SERIES 501		8	1.00	1.00	
43033	PCB 100-SERIES 501		8	1.00	1.00	
49003	SPACER FF 4-40x.500 AL HX		2	1.00	1.00	
49018	BRACKET RIGHT ANGLE		2	1.00	1.00	
49030	JACK TEST SIDE ENTRY	TP101	6	1.00	1.00	
81005	CAP 47 uF 16V ELEC	C103,106	2	2.00	2.00	
81006	CAP 470 uF 10V ELEC	C107	8	1.00	1.00	
83004	CAP .001 uF 100V DISC	C109	2	1.00	1.00	
83009	CAP .1 uF 12V DISC	C108	8	1.00	1.00	
84013	CAP .1 uF 100V FILM	C101,102	8	2.00	2.00	

KITTING LIST

5010005 501 PCB ASBY 5-ST SW RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL ***	B	99	.00	.00	
42037	HEDR 22-S .100 RYANG GOLD	J301	12	1.00	1.00	
42043	HEDR 16-P .100 GOLD	H301	6	1.00	1.00	
43014	PCB 300-SERIES BOTTOM		8	1.00	1.00	
43020	PCB 300-SERIES TOP		8	1.00	1.00	
45016	BUTTON SQUARE GREY		2	1.00	1.00	
45018	BUTTON SQUARE BLUE		2	4.00	4.00	
49028	SPACER DOG BONE .093"H		2	8.00	8.00	
52009	SW PB 5-STA 4-POLE	S301	8	1.00	1.00	

KITTING LIST

5010006 501 PCB ASBY 2-ST SW RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL ***	C 3-20-85	99	.00	.00	
42039	HEDR 10-P .156 LOK	H402	6	1.00	1.00	
42041	HEDR 16-S .100 GOLD	J401	6	1.00	1.00	
42051	HEDR 10-P .100 GOLD	H401	6	1.00	1.00	
43015	PCB 400-SERIES 501	NO REV	8	1.00	1.00	
45017	BUTTON SQUARE RED		2	2.00	2.00	
47009	INSUL NEOPRENE.5x2.5x1/16		2	1.00	1.00	
49026	SPACER DOG BONE .093"H		2	4.00	4.00	
52010	SW PB 2-STA 4-POLE	S401	8	1.00	1.00	

KITTING LIST

5010012 501 FRONT PANEL ASBY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL ***	H 10-14-85	99	.00	.00	
01004	NEON LIGHT RED	N1	6	1.00	1.00	
01007	NEON LIGHT	N3-5	6	3.00	3.00	
01008	NEON LIGHT RED	N2	6	1.00	1.00	
12005	SCR PAN 4-40x3/8 SS SLOT	AUS 2	2	.00	.00	
12014	SCR PAN 8-32x7/8 SS SLOT	EUR 2	2	.00	.00	
14005	NUT HEX 8-32 SS	EUR 2	2	.00	.00	
14008	NUT HEX 15/32-32		2	2.00	2.00	
14009	NUT BEV 15/32 BLACK		2	2.00	2.00	
15002	LOCKNUT 4-40 STEEL		2	5.00	5.00	
16006	LKWSHR #4 INT TOOTH SZ	AUS 6	2	.00	.00	
16009	LKWSHR #6 INT TOOTH STEEL	EUR 2	2	.00	.00	
18004	NUT 4-40 B/W NYLON		2	3.00	3.00	
31105	RES 1.0M OHM 5% 1/4W	R701,702,705	2	3.00	3.00	
31304	RES 300.0K OHM 5% 1/4W	R703,704,706	2	3.00	3.00	
31333	RES 33.0K OHM 5% 1/4W	R1 AUS 1	2	.00	.00	
31333	RES 33.0K OHM 5% 1/4W	R1 EUR 1	2	.00	.00	
31333	RES 33.0K OHM 5% 1/4W	R1 S AF 1	2	.00	.00	
31333	RES 33.0K OHM 5% 1/4W	R1 UK 1	2	.00	.00	
31514	RES 510.0K OHM 5% 1/4W	R701-706 UK6	2	.00	.00	

KITTING LIST

5010012 501 FRONT PANEL ASBY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
31514	RES 510.0K OHM 5% 1/4W	R701-706AUS6	2	.00	.00	
31514	RES 510.0K OHM 5% 1/4W	R701-706EUR6	2	.00	.00	
31514	RES 510.0K OHM 5% 1/4W	R701-706SAF6	2	.00	.00	
42001	BANANA JACK RED		6	2.00	2.00	
42002	BANANA JACK BLACK		6	2.00	2.00	
42004	BANANA JACK GREEN		6	2.00	2.00	
42014	RECPT. AUSTRALIAN CHASSIS	J5 AUS 1	6	.00	.00	
42025	TERM FORK #8 18-14GA INS		2	1.00	1.00	
42036	TERM RING #6 16-14 GA INS		2	2.00	2.00	
42045	RECPT EUROPEAN CHASSIS	J5 EUR 1	6	.00	.00	
42053	TERM FTAB .250 16-14 INS		6	8.00	8.00	
42056	TERM FTAB .250 12-10 INS		6	3.00	3.00	
42058	TIE WRAP 3"		2	3.00	3.00	
42062	INDS 10-S .156 22GA	J1	6	1.00	1.00	
42069	TERM FORK #8 22-16 GA INS		6	1.00	1.00	
42070	TERM FTAB .187 22-18 GA		2	2.00	2.00	
42071	INDS 5-S .156 22 GA	J4	6	1.00	1.00	
42086	TERM FTAB .250 22-18 INS		6	2.00	2.00	
43006	PCB 250M-3/501 NEON LIGHT		8	1.00	1.00	
44047	OVERLAY 501 FRONT'		8	1.00	1.00	

KITTING LIST

5010012 501 FRONT PANEL ASBY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
49017	SPACER FF 2-56x.500 BR HX		6	4.00	4.00	
49018	BRACKET RIGHT ANGLE		2	2.00	2.00	
49093	SPACER FF 4-40x.187 NI HX	AUS 2	3	.00	.00	
5010016	BRACKET 501 AUSTRALIAN	AUS 1	10	.00	.00	
5010017	PANEL 501 FRONT EUROPEAN	EUR 1	10	.00	.00	
5010020	BRACKET 270/501 EUROPEAN	EUR 1	90	.00	.00	
5010021	PANEL 501 FRONT	AUS 1	10	.00	.00	
5010021	PANEL 501 FRONT	S AF 1	10	.00	.00	
5010021	PANEL 501 FRONT	UK 1	10	.00	.00	
5010021	PANEL 501 FRONT		10	1.00	1.00	
55001	SW TOGGLE SPST 15A	REF 14008	12	1.00	1.00	
55003	SW TOGGLE DPDT 3-POS 20A	REF 14008	12	1.00	1.00	
71003	CABLE RIBN 10-CON 22 AWG	6"	2	.50	.50	
71013	WIRE 1-COND 22 AWG	BROWN 11"	2	.92	.92	
71013	WIRE 1-COND 22 AWG	WHITE 11"	2	.92	.92	
7770018	RECEPT HOSPITAL *42047	J5 S AF 1	90	.00	.00	
7770018	RECEPT HOSPITAL *42047	J5 UK 1	90	.00	.00	
7770018	RECEPT HOSPITAL *42047	J5	90	1.00	1.00	
83013	CAP 150 pF 1000V DISC	C1	8	1.00	1.00	

KITTING LIST

5010013 501 BACK PANEL ASBY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL ***	J 08-01-86	99	.00	.00	
12005	SCR PAN 4-40x3/8 SS SLOT		2	4.00	4.00	
12019	SCR PAN 4-40x3/16 SS SLOT		2	1.00	1.00	
15002	LOCKNUT 4-40 STEEL		2	4.00	4.00	
17001	WSHR FLAT #8 SS		2	4.00	4.00	
19003	RIVET POP 1/8D .060-.125G		2	4.00	4.00	
19006	RIVET POP AL HEAD/ST SHNK		2	4.00	4.00	
19007	RIVET POP AL HEAD/ST SHNK		2	4.00	4.00	
33013	RES 1.00K OHM 1% 25W	R1	8	1.00	1.00	
33014	RES 300.00 OHM 5% 20W	R2	8	1.00	1.00	
42008	PLUG HOSP GRA CABLE		6	1.00	1.00	
42027	TERM RING #8 16-14 GA INS		6	1.00	1.00	
42028	BINDING POST, GND		6	1.00	1.00	
42053	TERM FTAB .250 16-14 INS		6	6.00	6.00	
42062	INDS 10-S .156 226A		6	1.00	1.00	
44114	OVERLAY 501 BACK PANEL		8	1.00	1.00	
46001	FUSE 1/4A 3AB W/ BOX	F1	6	1.00	1.00	
46003	FUSE 1A	F3	8	1.00	1.00	
46004	FUSE 10A 250V 3AB W/ BOX	F2	6	1.00	1.00	
46007	FUSE 15A SLOW BLOW	F2	6	1.00	1.00	

KITTING LIST

5010013 501 BACK PANEL ASBY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
46008	FUSEHOLDER 3AG ROUND		6	3.00	3.00	
47006	BATTERYCLAMP		2	2.00	2.00	
47007	BATTERY PACK 4 4.8V NICCD		10	2.00	2.00	
47008	BATTERYBRACKET		8	1.00	1.00	
47009	INSUL NEOPRENE.5x2.5x1/16		2	4.00	4.00	
49019	STRAINRELIEF FOR SJT 14/3		2	1.00	1.00	
49032	CORDWRAP PLASTIC BLACK		6	2.00	2.00	
5010028	PANEL 501 BACK		10	1.00	1.00	
5010034	RUBBER INSULATOR 31/2X3/4		90	1.00	1.00	
71001	POWERCORD 14/3 SJTO		2	6.00	6.00	
71003	CABLE RIBN 10-CON 22 AWG	A/R	2	.00	.00	
71012	POWERCORD 14/3 EUROPE	220V ONLY	2	.00	.00	
7770106	WASHER,STRAIN RELIEF		90	1.00	1.00	

KITTING LIST

5010014 501 CASE ASBY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL *** G 11-14-85		99	.00	.00	
12027	SCR PAN 10-32x5/8 SS SLOT		2	2.00	2.00	
12036	SCR PAN 6-32x7/16 SZ SLOT		2	5.00	5.00	
16009	LKWSHR #6 INT TOOTH STEEL		2	5.00	5.00	
16011	LKWSHR #10 INT TOOTH SZ		2	2.00	2.00	
18014	WSHR FLANGED #6 NYLON		2	5.00	5.00	
19004	SCR PAN #6x1/2 ST #2PHIL		2	4.00	4.00	
19006	RIVET POP AL HEAD/ST SHNK		2	4.00	4.00	
19008	RIVET POP AL HEAD/ST SHNK		2	2.00	2.00	
42034	TERM RING #6 22-16 GA INS		2	5.00	5.00	
42058	TIE WRAP 3"		2	1.00	1.00	
42071	INDS 5-S .156 22 GA		6	1.00	1.00	
44040	BEZEL LONG BLACK	PCS,NOT PAIR	90	2.00	2.00	
44041	BEZEL SHORT BLACK	PCS,NOT PAIR	10	2.00	2.00	
48041	ADAPTER EC6		6	5.00	5.00	
48042	ADAPTER RETAINER EC6		6	5.00	5.00	
49026	HANDLE		6	1.00	1.00	
49041	CORDWRAP BLACK		6	1.00	1.00	
49045	LABEL INST/WARN 501		6	1.00	1.00	
49064	FOOT RUBBER 3/16"SQ BLK		2	2.00	2.00	

KITTING LIST

5010014 501 CASE ASBY RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
49222	TILT BAR		6	1.00	1.00	
5010023	CASE 501 TOP		90	1.00	1.00	
5010033	CASE 501 BOTTOM		90	1.00	1.00	
71013	WIRE 1-COND 22 AWG	A/R	2	.00	.00	
7770012	WSHR STRIP		90	1.00	1.00	

KITTING LIST

5010015 501 ACCESSORIES RUN # QTY: 1

PART #	DESCRIPTION	REFERENCE	MEMO CODE	QTY	EXT	ISSUES
*	*** REVISION LEVEL ***	G 11-26-85	99	.00	.00	
42058	TIE WRAP 3"		2	2.00	2.00	
46001	FUSE 1/4A 3AB W/ BOX		6	1.00	1.00	
46003	FUSE 1A		8	1.00	1.00	
46004	FUSE 10A 250V 3AB W/ BOX		6	1.00	1.00	
46007	FUSE 15A SLOW BLOW		6	1.00	1.00	
48001	PROBE RED		6	1.00	1.00	
48002	CLAMP PIGMY HIPPO		6	1.00	1.00	
48004	ADAPTER BULLET GROUND		6	1.00	1.00	
48005	ADAPTER GROUND		1	1.00	1.00	
48011	PLUG BANAND MALE BLACK		6	1.00	1.00	
48013	PLUG BANANA MALE RED		6	1.00	1.00	
48037	BAR SHORTING RED OR BLK		8	2.00	2.00	
48039	PLUG DOUBLE BANANA RED		8	1.00	1.00	
48044	PLUG DOUBLE BANANA BLK		6	1.00	1.00	
71004	WIRE 2-COND 20 AWG		2	5.00	5.00	

APPENDIX A: NICKEL-CADMIUM BATTERIES

A.1 Battery Care

The Model 501 comes equipped with a 10 V rechargeable nickel-cadmium battery pack designed to provide years of reliable service. In general, these batteries require no special maintenance.

Two particular characteristics of nickel-cadmium batteries which might be noted however, are:

1. their memory effects and
2. their shelf life.

If the battery pack is only partially discharged between charges (before the Lo Bat light comes on), it's ability to deliver voltage will be slightly reduced. In effect the batteries *memorize* their previous short cycling history. This memory may be erased by discharging the batteries and then recharging; the discharge may be accomplished by leaving the Model 501 on until the front panel low battery indicator comes on and then allowing recharging for 14-16 hours. The memory effect need not be of concern for the average user and is noted to explain length of running time characteristics of the Model 501.

The Model 501 batteries have an indefinite shelf life. The user may find that after a couple months of storage, the batteries will need a charge before use. Otherwise, no particular consideration needs to be given to long-term storage.

A.2 Charging

The batteries will come to full charge in 14-16 hours of charging. (To charge, turn the Model 501 OFF and plug into a wall receptacle.) This charging time will allow continuous Model 501 operation for at least 8 hours.

For maximum battery life, it is recommended that the charge be removed after the batteries reach full charge (16 hours).

If your Model 501 was designed for 110 VAC, you can still plug it into a 220 VAC power supply to test 220 VAC equipment; however, to avoid damage to the Model 501 battery pack:

1. Plug the Model 501 into a 220 VAC power supply for testing, ONLY if your 501 is in the fully charged condition.
2. Under no condition should the Model 501 be in the OFF/CHARGING mode while plugged into a 220 VAC power supply. (These precautions do not apply for models made for 220 VAC.)

A.3 Battery Replacement

The life of nickel-cadmium batteries depends on many factors. In terms of charge/discharge cycles, life expectancy can be anywhere in the range of 500 to 30,000 cycles. With the Model 501, one can typically expect 100 charge/discharge cycles, providing years of continuous use.

New batteries may be obtained directly from Bio-Tek Instruments; order: 2-each, Battery Packs, Part Number 47007 and 1-each Insulator, Part Number 47010.

To replace the battery pack, first remove the bottom panel of the Model 501, then slide the Model 501 case off from the front and back panels. Remove the back panel further by a single screw which secures the panel to an interior strengthening bar (see Figure 2.1-1 for location of the screw on the front panel). The battery bracket is then removed by 4 screws securing it. Note exactly how the batteries are fixed within the bracket (battery polarity is important). Carefully unsolder the wires to the battery. Resolder the wire to new batteries and reassemble. (Do not forget to replace the insulation between the 2 battery packs.)

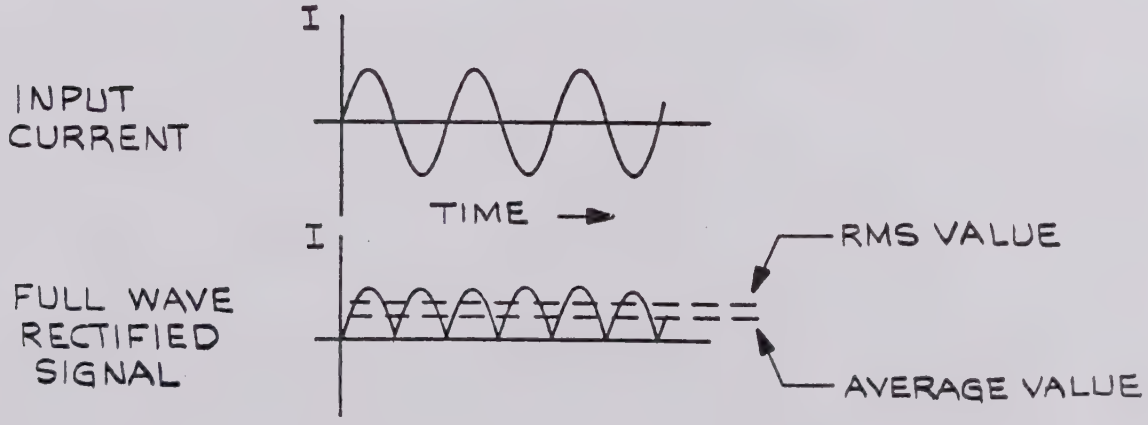
APPENDIX B: TRUE RMS READING VERSUS AVERAGE FULL WAVE RECTIFIED (RESPONDING RMS CALIBRATED)

The Model 501 Digital Safety Analyzer measures the true value of AC, DC, and the combination of AC and DC leakage current and is called the root mean square (RMS) value. This value is different from the typical system leakage current measurement that calculates the average of the input signal and then multiplies by a factor that approximates the RMS value.

Full-wave rectified, average responding, RMS calibrated is the technique the majority of current and voltage measuring systems use. Basically, the input signal is full-wave rectified which converts all input signals to positive values. This rectified value is then averaged to give the average current or voltage. Many AC signals measured are sinusoidal so that a scale factor may be used to approximate the RMS value from the average value. The RMS approximated value is then the displayed result for the measurement. Graphically, this is displayed below for a typical AC signal.

For a pure sine wave signal the RMS current is 1.40 times the average current.

For other types of signals, the factor is different, and hence, the approximated RMS value is erroneous.



TRUE RMS VALUE

The only way to accurately determine the effective signal, if it is AC, or DC and AC, is to calculate the RMS of the signal. The technical equation for the RMS value of a periodic signal is:

$$I_{RMS} = \sqrt{\frac{1}{T} I(t)^2 \, dt}$$

where:

I = the mathematical description of the input signal

T = the period for the signal (the time the signal does not repeat itself).

This equation describes a process which involves squaring the input signal and converting any negative signal to a positive value. The signal is then summed over a period and the square root is calculated.

In the Model 501, this is the RMS conversion calculated automatically using state-of-the-art integrated circuitry. The benefit of true RMS measurement is in the evaluation of complex signals such as combined AC and DC or pulse signals.

APPENDIX C: FOUR-POINT RESISTANCE TECHNIQUE

To measure resistance, the Model 501 Digital Safety Analyzer uses a technique that negates any inaccuracies attributed to lead lengths. This is crucially important when measuring very low resistances because the resistance of the leads and interconnectors of the analyzer could be significant compared to the resistance to be measured.

The accepted technique for measuring resistance is to pass a known current through the resistance and measure the voltage across that resistance.

Using Ohms Law:

$$V = IR$$

where:

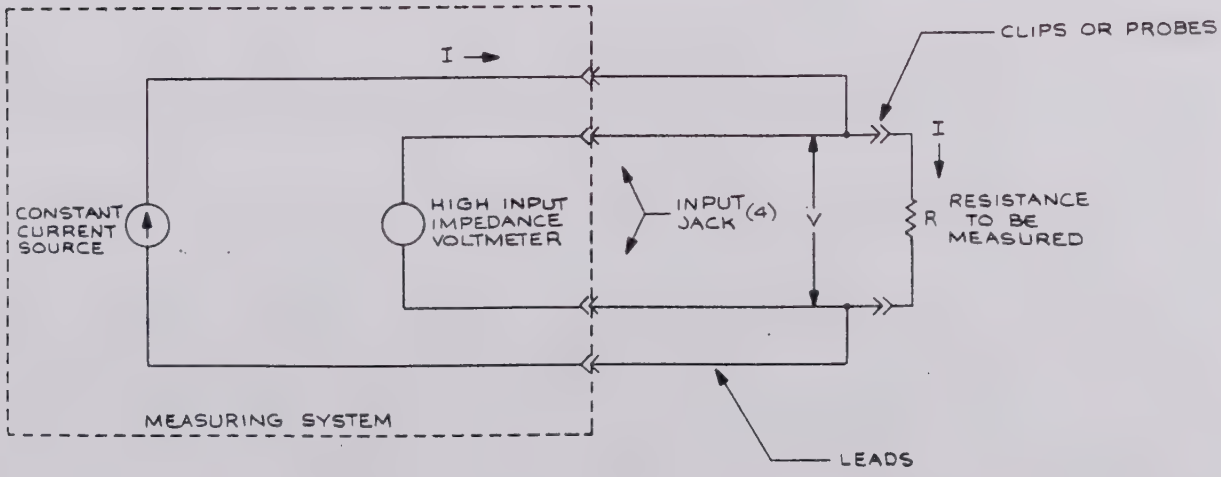
V = voltage

I = current

R = resistance.

Since the current is a known constant, the measuring system scales the voltage to be equal to the resistance.

The usual technique in a regular measuring system is shown below.



The constant current source provides a current, (I), which flows through the leads and the resistance to be measured. An insignificant amount of the current flows through the voltmeter because of the very high input impedance. There is a voltage to be measured at the voltmeter connector because of the current, (I), passing through the leads and the resistance, (R).

All matter has resistance. The voltage at the voltmeter is going to be the voltage developed by current going through all resistance in the system.

DESCRIPTION	RESISTANCE (TOTAL)
Internal Wiring Total	0.005
Input jacks, 0.005 ohms each	0.010
2 each 5' leads at 0.01 ohm/foot	0.10
Clips or probes at 0.01 ohm each	0.02
Total	0.135 ohm
Resistance to be measured	R
Total resistance through which the current passes	R + 0.135

The equation then is:

$$V = I(R + 0.135) .$$

If the resistance to be measured is 100 ohms, then the resistance for the leads becomes less than 0.01% of the total resistance. This is insignificant and below the accuracy of the measurement system.

If the resistance to be measured is 0.15 ohms, then the resistance of the leads, jacks and adapters becomes equal to 90% of the value of the resistance to be measured, introducing a 90% error.

There are two ways to measure small resistances. One relies on a manual adjustment for each measurement. The setup is the same as pictured in the front panel (as shown in Figure 2.1-1), except the voltmeter has an adjustment that allows subtraction from the reading for the resistance attributed to the measurement system. To accomplish this, the leads, probes and clips are connected together by shorting the ends of the leads. The current flows and any voltage measured is caused by the measurement system. The voltmeter has a zero adjustment which in effect subtracts the value of the lead resistance from the reading, then the measurement can be made with reasonable accuracy.

The Four-Point Measurement System operates in the same way as previously discussed except that the voltmeter is connected to the resistance by a separate pair of leads. The rationale for resistance measurement is based on the fact that the voltage measured is related to the resistance value. If the voltage measured does not include the voltage across the jacks, leads, and probes, then the true resistance will be measured. As with conventional resistance measurement, we assume that the voltmeter has a high input impedance so that insignificant current flows through the voltmeter.

The voltage measured is directly across the unknown resistance. The voltages occurring because of voltmeter leads and jacks have been eliminated from the constant current path. The true resistance is measured without interference.

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INSTRUMENTS, INC.
PUBLICATION NO. 04
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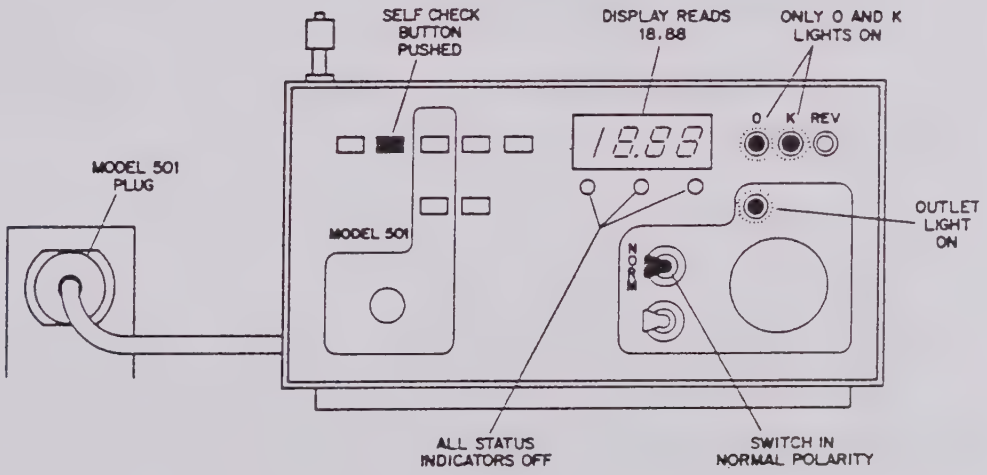
MODEL 501 SHORT FORM INSTRUCTIONS

BEFORE FIRST USE, READ THE MODEL 501 INSTRUCTION MANUAL FOR PROPER USE INFORMATION.

SYSTEMS CHECK

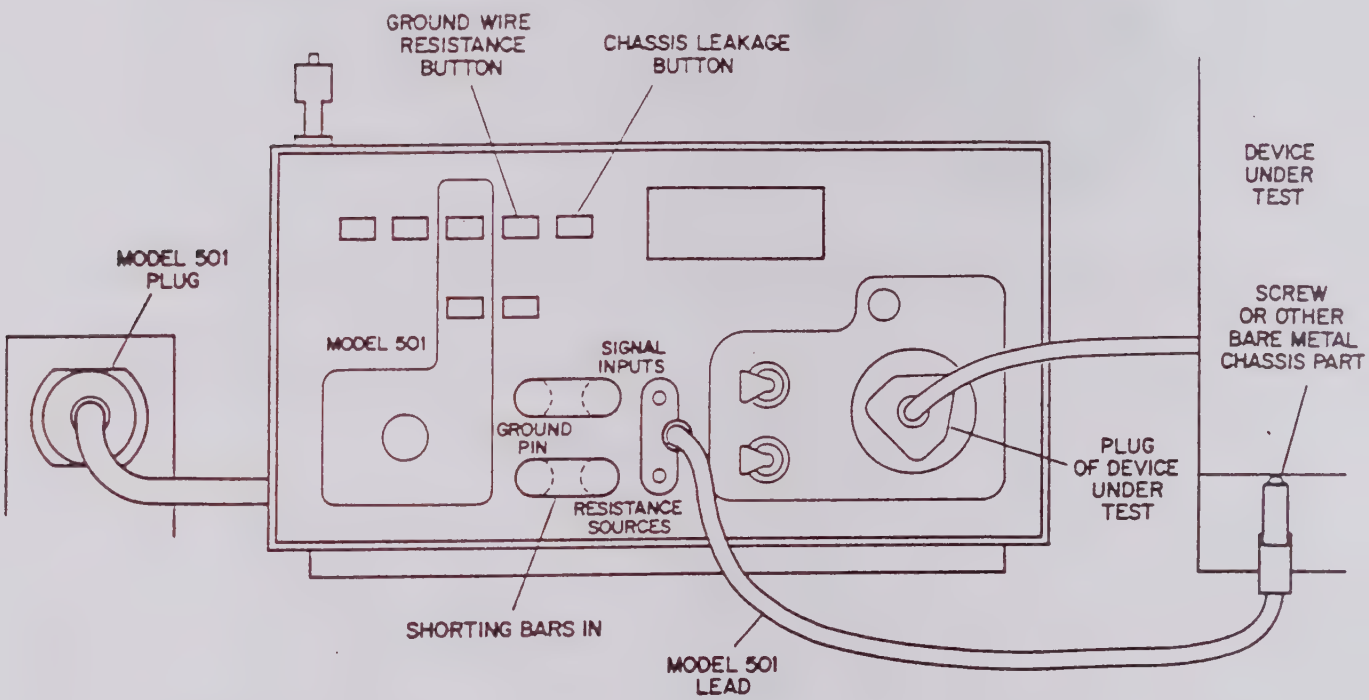


SYSTEMS CHECK FUNCTIONS

1. Push the Systems Check button.
2. The following results should be obtained for proper operation.
   a. The Display should read **18.88**
   b. The "O" and "K" lights of the Receptacle Check System should be **ON**
   c. All the status indicators, low battery, over range, and battery charging lights should be OFF
   d. With the Polarity switch in "NORMAL", the Outlet light should be **ON**

PORTABLE DEVICE TESTING

CHASSIS LEAKAGE AND GROUND WIRE RESISTANCE



1. MAKE THE FOLLOWING CONNECTIONS:

   a. The Model 501 plug to a tested receptacle.
   b. The device under test to the Model 501 receptacle.
   c. Shorting bars between the black and green jacks.
   d. Red lead dual plug to the Model 501 red jacks.
   e. Large clamp (or probe) to the red lead single plug.
   f. The large clamp (or probe) to the chassis of the device under test.

2. Push the "Chassis Leakage" button. Record the reading in microamps or millivolts in each of the following receptacle switch configurations. (Note: In changing the polarity of motorized devices, go to center "OFF" for several seconds.)

   Normal Polarity - Ground
   Reverse Polarity - Ground
   Reverse Polarity - No Ground
   Normal Polarity - No Ground

   Recommended standard (AAMI, 76B): Patient applied equipment - 100 microamperes; nonpatient equipment - 500 microamperes.

3. Ground Wire Resistance

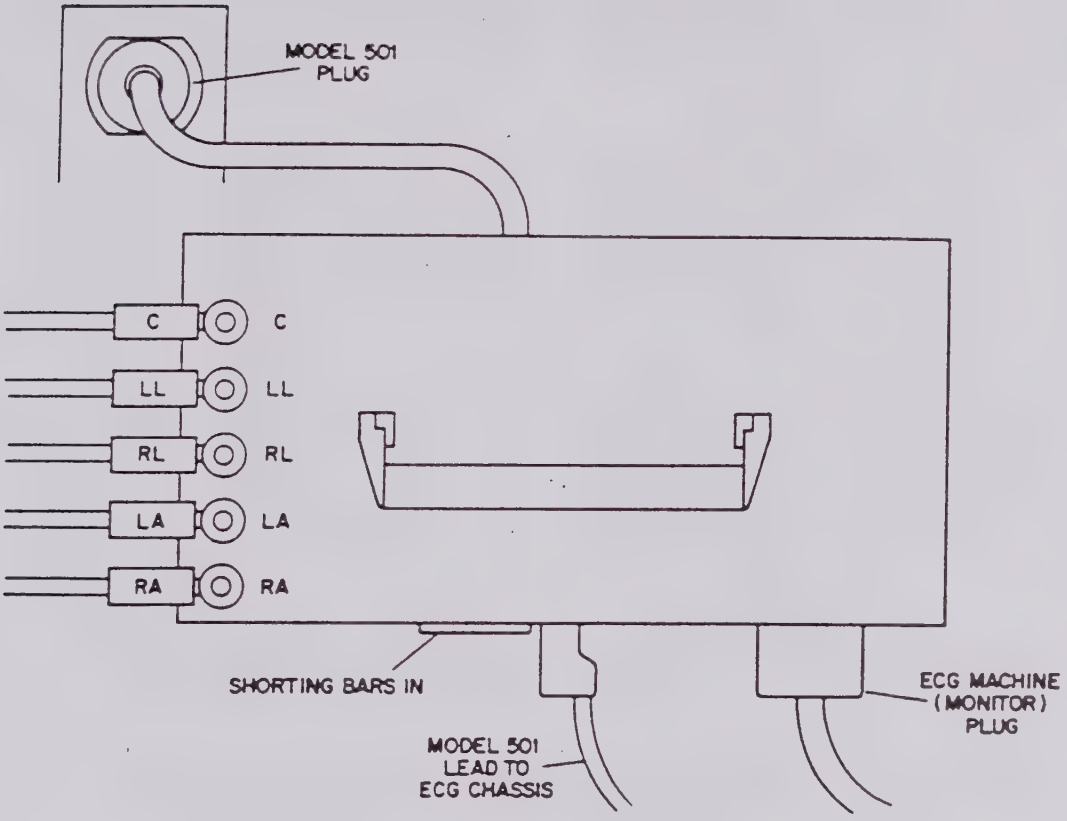
   Push the "Ground Wire Resistance" button and record the reading in ohms.

   Recommended standard (76B): 0.15 ohms

MANUFACTURERS OF A COMPLETE LINE OF
MEDICAL TEST EQUIPMENT

ECG LEAD TESTING

LEAD LEAKAGE CURRENT AND ISOLATION



1. Connect the ECG leads to the Universal ECG jacks.
2. Push the "ECG Lead Leakage" button.
3. Rotate the "ECG Lead" switch to each position and record the highest reading and the lead which had it. Repeat this for all the power configurations.

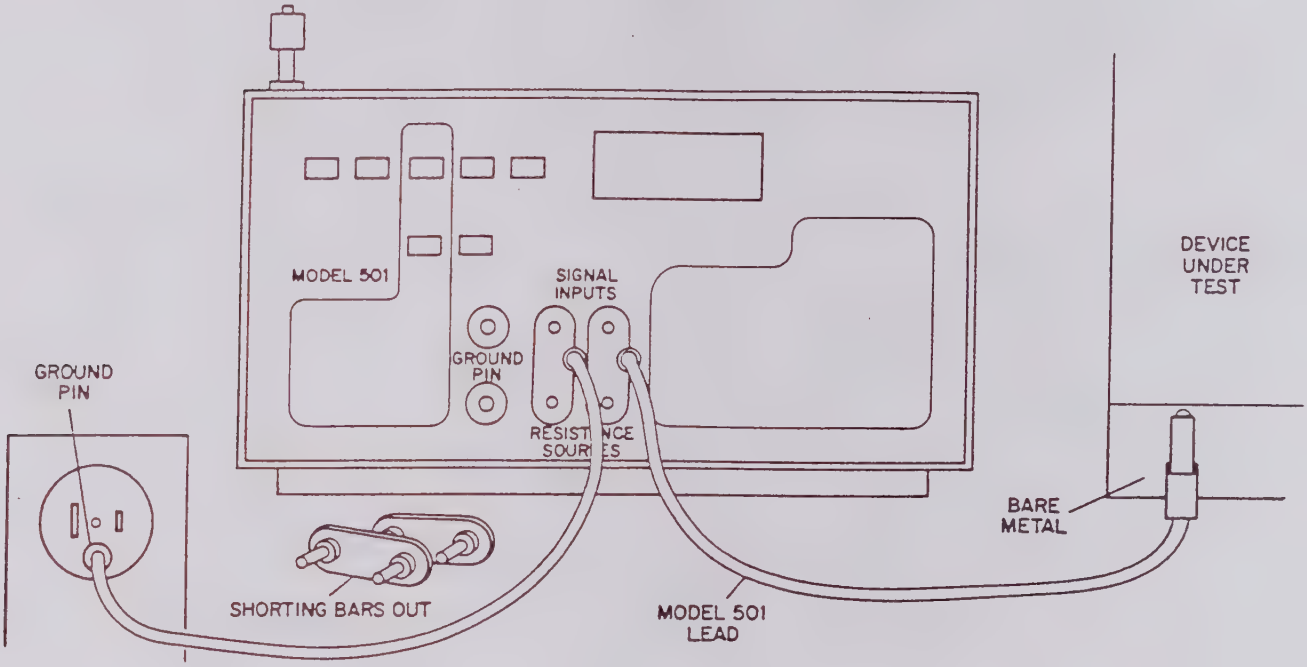
   Recommended standard (AAMI): 20 microamperes from any lead.

FOR ISOLATED LEADS ONLY

1. Push the "ECG Lead Leakage" button and "ECG Lead Isolation" button.
2. Rotate to each lead position.
3. Record the isolation reading less the meter factor of approximately 5 uA.

   Recommended standard (AAMI): 20 microamperes; the Model 501 will read 25.0 microamperes (20 uA plus 5 uA for meter factor).

TWO LEAD LEAKAGE AND RESISTANCE MEASUREMENT SET UP



1. Connect the leads to the Model 501 as shown above.
2. Connect the black lead to a ground point such as a receptacle plate.
3. Connect the red lead to the device under test.
4. Push "Chassis Leakage" button.

   Read the display in microamps or millivolts with the device ON and OFF.
5. Push "GRD Wire Resistance" button. Record resistance in ohms.

Bio-Tek Publications Concerning Testing

Model 501 Instruction Manual
Electrical Safety Program Guide
Electrical Safety Primer

Call 800-451-5172 For Additional Information

CAUTION: This shortform instruction is designed as an aid in using the Model 501, once the operator manual has been thoroughly read. This instruction sheet assumes the user understands the basic safety and proper use information, detailed in the instruction manual.

WARNING

CHECKING CHASSIS LEAKAGE AND LEAKAGE CURRENTS WITH BIO-TEK SAFETY ANALYZERS

Bio-Tek manufactures a complete line of electrical safety analyzers. From our experience, we recommend performing the following steps to prevent the creation of potentially hazardous conditions for the operator:

1. Take Ground Wire Resistance measurements with the polarity switch in the OFF position.

2. Take Leakage Current measurements only after the Ground Wire Resistance has been measured.

The National Fire Protection Agency recommends testing in this order in their publication NFPA 99.

Part #99180

BIO-TEK
INSTRUMENTS, INC.

Application Note

ELECTRICAL SAFETY ANALYZERS
(Models 170, 270, 501)

TYPE OF TEST: Neutral To Ground Resistance Testing.

RESULT: Sometimes during the neutral to ground resistance testing the Bio-Tek Electrical Safety Analyzer(s) may give erratic readings.

During this test procedure the safety analyzer applies a fixed current (-10ma DC; -25ma DC; 10ma DC for 170, 270 and 501 Models respectively) between the neutral and ground wires. The resulting voltage drop due to the unknown resistance between the two wires is measured with an amplifier. A measure of this voltage drop is displayed by the analyzer as the resistance between the neutral and ground wires.

EXPLANATION: The amplifier circuit mentioned above also has a low pass filter that rejects 50 or 60 Hz, 100mv line interferance. However, it is not unusual for much larger amplitude (several volts) signals, of 50/60 Hz or other frequencies, to be floating in the hospital wiring system. These interferences may be due to improper wiring, shielding, distribution system, or grounding. Ground loops and/or appliances and equipment (CAT Scanners, X-Ray equipment, etc.) used in the establishment may also contribute towards extraneous signal levels.

The low pass filters in the safety analyzers are not designed to eliminate the large signal interference described above. Thus the apparent voltage drop perceived by the safety analyzers' amplifier circuits will not be accurate, resulting in the erratic readings.

SOLUTION:

1. Perform the test with all other appliances and devices connected to the same distribution system unplugged.

2. If the erratic readings persist, you can make a choice between (a) ignoring and eliminating this test or (b) taking steps to have a better wiring, distribution and grounding system.

REMEMBER: THE NEUTRAL TO GROUND RESISTANCE TEST IS NOT REQUIRED BY ANY NATIONAL OR INTERNATIONAL STANDARDS.

CALL TOLL FREE 800-451-5172

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